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LODGEPOLE
Blowout Report

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LODGEPOLE BLOWOUT INQUIRY

PHASE 1 REPORT

REPORT TO THE LIEUTENANT GOVERNOR IN
COUNCIL WITH RESPECT TO AN INQUIRY HELD
INTO THE BLOWOUT OF THE WELL, AMOCO DOME
BRAZEAU RIVER 13-12-48-12

DECEMBER 1984

LODGEPOLE BLOWOUT INQUIRY PANEL

LODGEPOLE BLOWOUT INQUIRY PANEL
DECISION REPORT

Report D 84-9 concerns

The blowout of the well, AMOCO DOME BRAZEAU RIVER 13-12-48-12, which blew out of control on 17 October 1982.

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ERCB

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The Lodgepole 13-12 well on fire with rig debris being removed.

Photo credit: W. Wylie, ERCB

1 SUMMARY

INTRODUCTION

17 October 1982 will likely be a significant date in Alberta's history. It was on that day at 14:30 that the well, AMOCO DOME BRAZEAU RIVER 13-12-48-12 (13-12 well), located 20 kilometres (km) west of the small hamlet of Lodgepole, blew out of control. For over 2 months specialists fought to regain control of the well and were finally successful on 23 December 1982.

People residing near the blowout were significantly affected by events during the 67 days. At times, the odours were severe and people feared for their health and safety. Even people far removed from the area were subjected to the unpleasant odours, depending on atmospheric conditions.

The blowout will likely have a significant impact on the Alberta gas industry, particularly with respect to drilling sour gas wells.

A public inquiry was convened to learn what happened, why it happened, and how it might be avoided in the future. The Inquiry Panel's (Panel) views on these questions are provided in this summary.

WHAT HAPPENED AT LODGEPOLE?

In August 1982, Amoco Canada Petroleum Company Ltd. (Amoco) applied to the Energy Resources Conservation Board (ERCB) for a licence to drill a well to be located 20 km west of the hamlet of Lodgepole, Alberta. The well was spudded on 10 August 1982 and was drilled to about 3000 metres (m) without significant incident. Intermediate casing was then installed prior to drilling into the expected productive formation. On 15 October, the drilling crew began coring into the zone and the first two cores were obtained without apparent problems. On 16 October, the crew proceeded with core No. 3, but halted coring operations when evidence of fluid influx from the formation was detected.

For the next 16 hours, the crew fought to regain control of the well but finally, at 14:30 on 17 October, the well blew out of control. In spite of numerous measures to regain control, the sour gas blowout persisted for 67 days with control finally being regained on 23 December 1982.

THE INQUIRY

On 14 January 1983, the ERCB announced that an inquiry would be held to determine the facts surrounding the Lodgepole blowout. The inquiry was held in two phases and this report deals with Phase 1, the analysis, findings, and recommendations regarding the blowout itself.

IMPORTANT ISSUES

As a result of several public pre-inquiry meetings with participants, the Panel determined that the following were the most important issues to be addressed:

> What were the factors contributing to the Lodgepole blowout and what actions were taken to prevent it? Were these actions adequate?
>
> What significant factors contributed to regaining control of the well? Were control actions adequate?
>
> Was there a hazard to human health and, if so, was the effect measurable? What steps were taken to minimize the effect and were the steps adequate?
>
> Was there an impact on the environment and, if so, how serious was it? What steps were taken to reduce the impacts and were the steps adequate?
>
> Were ERCB and Government department regulations, policies, and procedures adequate? Were the responses to the emergency following the blowout adequate?

Additionally, the Panel decided it should examine, quite separately from the 13-12 incident, the more general question of whether further actions should be taken to minimize the possibility of future blowouts in Alberta. That assessment took place following the main inquiry and the Panel's conclusions were provided in its Phase 2 report issued in April 1984.

WHAT WENT WRONG AT THE 13-12 WELL?

The drilling plan for the 13-12 well included cutting cores in the productive formation. While cutting the third core on 16 October, reservoir fluids, including sour gas, unexpectedly entered the wellbore resulting in what the industry calls a "kick". Amoco was unsuccessful in controlling the kick and after a 16-hour battle, totally lost control of the well on 17 October.

Why did the kick occur? Unfortunately, it is not possible to be certain as to all of the developments that occurred on 16 and 17 October. Nevertheless, the Panel's reconstruction of those events leads it to conclude that the initial kick occurred primarily because drilling practices during the taking of cores No. 2 and 3 were deficient and, when combined with the marginally adequate mud density being used, this permitted the entry of reservoir fluids into the wellbore.

The Panel also has concluded that the kick was likely not controlled because

(a) the drilling crew did not immediately recognize the problem and therefore did not immediately apply and maintain standard kick-control procedures,

(b) several pieces of vital equipment did not function properly, including:

  (i) casing pressure instruments,
  (ii) the degasser,
  (iii) drill pipe, and
  (iv) travelling block hook latch, and

(c) supplies of mixed drilling mud were not adequate during the kick-control operations.

In summary, the Panel concludes that no single element in the chain of events was the sole cause of the blowout. The unexpected entry of reservoir fluids into the wellbore was probably due to a combination of Amoco not adhering to sound drilling practices and only marginally adequate mud density. If the degasser had operated effectively, the initial kick might have been circulated out of the system, and subsequent kicks would likely have been avoided. Even with the failure of the degasser, control might have been maintained if there had been sufficient and properly weighted mud on hand to pump into the well. Additionally, if the casing pressure instruments had been operational from the outset, the crew might have recognized the kick at an earlier stage and implemented standard kick-control procedures when fluid influx was still relatively small. If the decision had been made to use hydrogen-sulphide- (H_2S) resistant pipe for the full drill string, the pipe might not have parted and the succession of kicks might still have been successfully circulated out. And finally, if the travelling block hook latch had not failed, it may have been possible to retain control of the well by "top kill" methods.

Were Amoco's actions satisfactory respecting these various developments? Amoco indicated that its program was based, from the outset, on the possibility but not an expectation of encountering sour gas. The Panel is satisfied that Amoco applied reasonable judgement with respect to the selection of the Nabors rig, approving the degasser, and to a lesser degree, in selecting the type of drill pipe to drill the well, even though, with hindsight, the latter two turned out to be inadequate for the conditions that developed. On the other hand, the Panel believes Amoco's actions were deficient with respect to:

(a) drilling practices during coring operations (cores No. 2 and 3),

(b) implementation of standard kick-control procedures,

(c) ensuring adequate mixed drilling mud was available at all times, and

(d) maintaining equipment in satisfactory operating condition (casing pressure instruments).

It appears to the Panel that the fundamental problem was that Amoco did not apply the necessary degree of caution while carrying out operations in the critical zone. Amoco did not appear to be sufficiently aware of the potential for problems that could occur when coring into the porous zone and thus the need to be fully prepared in the event of a fluid influx. Consequently, when a kick developed, there were delays in responding to it. Then, when equipment problems occurred and supplies of mixed mud were inadequate, Amoco was forced into further delays of precious time in implementing kick-control actions.

In summary, it is clear to the Panel that the major area of deficiency relates to the "human factor" which was so extensively referred to during the Phase 2 portion of the inquiry.

The Panel has made a series of recommendations aimed at reducing the possibility of future blowouts. Several have already been implemented, or are being studied. Anyone interested in the detailed assessment of the cause of the blowout, or the Panel's specific recommendations, is invited to review section 5 of this report.

REGAINING CONTROL OF THE 13-12 WELL

It required 67 days to regain control of the 13-12 well. Why did it take so long?

The Panel believes that several factors were instrumental in the delay:

1 The well was particularly difficult to tame.

The flow rate from the well was much higher than originally estimated. Also, the flow contained large volumes of condensate and a high percentage of H_2S, both of which became serious inhibiting factors to regaining control. Indeed, the Panel believes it would be difficult to find a more serious and difficult blowout to control.

2 Weather conditions were frequently unfavourable.

Because of the high flow rate from the well, and its high H_2S content, work on the well was possible only when there was sufficient wind to disperse the gas. Frequently, atmospheric conditions were relatively calm, and for more than 8 days out of the 26 days that the well was not on fire, weather conditions at the well site prevented the control crews from working.

3 Amoco's safety procedures and equipment, while appearing to be typical for the industry, were not adequate to cope with the magnitude and type of emissions from this particular well. As a result, a serious accident interrupted an operation that might have been successful with a less difficult well, and resulted in a further well control delay of 37 days.

Initially, Amoco and the ERCB had concluded that only two well control options were available: capping the well while it was not on fire, or drilling a relief well. Since the relief well would take up to 3 months to drill, with no assurance of success when completed, it was judged to be a last resort. After Amoco and the ERCB became aware of the damage to the casing bowl from the second fire and significant effects that the sour gas well emissions seemed to be having on the general public, consideration was given to a third control option, capping the well while it was on fire. Evidence at the inquiry indicated that this technique had been used only six times worldwide, and only on wells that were much smaller "blows" than the 13-12 well. While both Amoco and the ERCB recognized the serious risks inherent in this procedure, it was nevertheless selected because of the special circumstances. It eventually proved successful, but required another 21 days before it could be completed.

The difficulties encountered in regaining control of the 13-12 well, and the resulting impacts on the public, amply demonstrate the need to avoid such situations in the future.Once a well has blown out of control, the options available to the well control crew are limited. One of the benefits from the 13-12 experience was to learn that such a difficult well could be brought under control while it was on fire.

HAZARD TO HUMAN HEALTH

How did the emissions from the well affect the health of people residing in nearby regions?

The Panel heard evidence from 30 local residents, members of the Pembina Area Sour Gas Exposures Committee (PASGEC) at the formal inquiry, and 11 residents at the informal session, describing how the blowout had affected the health of members of their families. These effects were said to include headache, eye irritation, upper respiratory tract symptoms such as sore throat, nasal irritation, and nosebleeds in children, and lower respiratory tract symptoms, including pain on deep inhalation and some shortness of breath. The Panel also heard evidence from the Edmonton Area Respiratory Patients. Several of the PASGEC witnesses also referred to a similarity in the symptoms of illnesses in both people and livestock.

Various interpretations were placed on these submissions. Some participants at the inquiry contended that the problems related to a "flu epidemic", others to psychologically induced reactions. Others claimed that the noxious gas was the cause.

Unfortunately, there was a lack of scientific data available for analysis. Considering the large amount of circumstantial evidence, however, the Panel is satisfied that the well emissions did lead to at least short-term health effects for a substantial number of people, particularly in the Lodgepole area. The anecdotal evidence also strongly suggests that some people, especially those having respiratory problems, are much more likely to suffer unfavourable effects from H_2S gas.

What steps were taken by Amoco and Government agencies to protect the health and safety of persons living in the local area?

Although it was not set out in a single document, a protection plan was put in place which provided for:

(a) the establishment of a set of H_2S exposure limits designed to safeguard human health,

(b) the monitoring of actual H_2S concentrations throughout the area where people were residing, and

(c) arrangements for people to leave the area whenever H_2S concentrations exceeded the exposure limits. Where evacuation was deemed not practical, such as in Drayton Valley, the plan called for ignition of the well if H_2S concentrations exceeded the prescribed limits.

Exposure Limits

The protection plan was designed to ensure that if an H_2S concentration of 15 parts per million (ppm) was reached in any area where people were residing, then they would leave the area. Additional standards were identified for persons described as "sensitive", which generally was taken to mean persons with respiratory problems, very young children, the elderly, and pregnant women. However, for various reasons, these additional standards, while acknowledged, were not actually applied.

The appropriateness of the H_2S exposure limits was extensively debated at the inquiry. Particular concern was expressed about the need for much stricter standards for those persons judged to be more susceptible to H_2S.

The Panel recognizes the concerns about the standards, particularly regarding more stringent standards for sensitive people, and has recommended that this matter be given further consideration by the Provincial Board of Health (PBOH).

Monitoring H_2S Concentrations

The air monitoring program to determine actual H_2S concentrations in the general Lodgepole area was under the direction of Alberta Environment (AE). Stationary air monitors were installed in the nearby communities of Cynthia, Lodgepole, and Drayton Valley, and at the Brazeau Dam. Five mobile air monitors, four of them operating 24 hours per day, were used to check rural areas. Under the plan, three of the mobile monitors followed the highest H_2S concentrations as the plume moved through the area.

The monitoring data gathered during the event shows that the dispersion of the gas cloud from the well was actually quite rapid, notwithstanding the large volumes of H_2S gas being emitted. For example, no concentrations in excess of 10 ppm were found at any residences located farther than 20 km from the well, and there were only a few instances inside that 20-km radius. The highest concentration recorded at Cynthia was 14 ppm, at Lodgepole 14.5 ppm, and 5 ppm at Drayton Valley, some 45 km from the well. The highest reading in Edmonton was 0.5 ppm.

Throughout the 26-day period that the well was not on fire, H_2S concentrations were generally low. For example, at Lodgepole, the concentrations were less than 1 ppm for 87 per cent of the recorded hours, while at Cynthia and Drayton Valley they were less than 1 ppm for about 95 and 96 per cent of the time, respectively. In Edmonton, though the odour was detected, the H_2S concentrations were actually less than 0.1 ppm for 93 per cent of the time.

Evacuation

There were six occasions during the 26-day period that the well was not burning when concentrations at local residences reached the evacuation level of 15 ppm. All of these cases were in rural areas. Where they occurred, the people were notified and they left the area on a temporary basis. Additionally, Amoco advised that it was prepared to pay the costs for people who wished to leave the area because of effects from the emissions. A total of 28 individuals plus 4 families left on the basis of the Amoco offer.

IMPACT ON THE ENVIRONMENT

How serious was the environmental impact from the well emissions?

During the 67 days the well was out of control, there were daily emissions to the atmosphere of 150 to 450 tonnes of sulphur and 300 to 1100 cubic metres (m^3) of condensate. For the 26 days the well was not on fire, the condensate fell on the area immediately surrounding the well site and had an impact that was initially like that of an oil spill. Subsequent fires caused the lease area to be extensively burned. While this destroyed vegetation over a large area, it reduced long-term condensate pollution problems. During the period the well was on fire, the sour gas and condensate was combusted in the extremely intense fire and the H_2S was converted to sulphur dioxide (SO_2).

Obviously, emissions of that magnitude are certain to have some environmental impacts. Several studies were made to evaluate the extent of the impacts and the results were submitted to the inquiry. An area of some 300 hectares (ha) surrounding the well was the most seriously affected. There were major impacts on vegetation and soils in that area and minor impacts on surface water, groundwater, benthic organisms, mammals, and birds. Some of these impacts were ameliorated by quick remedial action. Due to the presence of residual condensate on the vegetation outside the burned and cleared areas and in the ground right around the well, there will continue to be impacts near the well site for some years on trees, groundwater, and soil.

To overcome the major impacts in the vicinity of the well, a program of short-term remedial measures and longer-term reclamation has been established. The program is comprehensive and should permit successful rehabilitation of the impacted area.

Sulphur emitted from the well, primarily in a gaseous form, was eventually deposited in low concentrations on the ground over an area of hundreds to thousands of square kilometres. There is no evidence that these levels of sulphur deposition will have long-term harmful effects on soils, vegetation, or water bodies.

RESPONSES BY ERCB AND GOVERNMENT DEPARTMENTS

Were ERCB and government regulations fully complied with during both the drilling and control operations at the 13-12 well?

Were the responses by the ERCB and Government departments appropriate during the emergency especially in terms of protecting the public?

The Panel did not find any evidence that Amoco had, in any significant manner, contravened either ERCB or government regulations. However, it did find that those regulations and policies need strengthening in several areas as they relate to the drilling of critical sour wells.

The Panel has made specific recommendations in several sections of this report to achieve that objective.

The Panel concluded that the response by the ERCB and Government departments was generally adequate, although improvements could be achieved particularly in the co-ordination of emergency response activities. A glaring deficiency by all parties related to communication with the public and the media during the blowout period. It was generally conceded by participants that efforts in this respect had been unsatisfactory and that major improvements were needed. The Panel believes that many of the problems relating to the public, that occurred during the incident, were directly attributable to inadequate communication. The Panel has recommended that a specific communication program be developed so that, in the event of another incident, the public can be kept properly informed and can have its concerns more effectively addressed.

WHAT ABOUT THE FUTURE?

One of the objectives of the inquiry was to identify actions which might be taken to significantly reduce the possibility of a future "Lodgepole". In order to consider that question, the Panel arranged for a separate phase of the inquiry (Phase 2) to consider evidence from drilling industry experts on how blowouts might be reduced. That phase resulted in a substantial number of recommendations by participants, most of which the Panel endorsed in its Phase 2 report, and which the ERCB is pursuing in conjunction with industry. Several of those recommendations are already in effect, although some are on a preliminary or trial basis only.

In its two inquiry reports, the Panel has made many recommendations that relate to drilling, well control, and impacts on the public. The important question is whether those recommendations, if implemented, would significantly reduce the likelihood of future blowouts. To test that proposition the Panel has, in section 13, reconstructed the 13-12 case, but has assumed that its various recommendations were in place and operating effectively prior to the licensing of the well.

From its test of this proposition, the Panel is reasonably certain the 13-12 blowout could have been avoided. Implementation of the Panel's recommendations can significantly reduce the number of blowouts in Alberta, provide some assistance in regaining control of any well where a blowout has occurred, and would play a major role in assisting the public during a blowout. Obviously, major attention should be directed to avoiding blowouts. To that end, the Panel's recommendations include changes in equipment, changes in procedure, and the strict observance of prescribed or accepted operating practices. Particular emphasis needs to be placed on the "human factor" which appears to be a root cause of blowouts. The Panel believes that an effective means of reducing the impact of human factor problems would be to require that operations in the critical zone be conducted in a very cautious and careful manner. To achieve that objective will require the commitment and direction of senior management of those companies drilling critical sour wells. The ERCB can assist by strengthening its inspection procedures and regulatory requirements.

CONCLUSION

The Panel's findings indicate that the 13-12 blowout could probably have been avoided, even allowing for equipment failures, if Amoco had followed a policy of cautious drilling in the critical zone and if Amoco had been better prepared to deal with unexpected developments. The public was understandably concerned, frightened, and angry about the blowout. Two workers lost their lives, and the public experienced widespread and unpleasant health effects. While the evidence suggests to the Panel that the actual long-term physical effects were relatively minor, the legacy of the Lodgepole blowout will permeate the Alberta scene for many years. This is a matter that will require special attention by industry, the ERCB, and Government departments. Special efforts must be made by all parties to avoid another occurrence, if at all possible, and to more effectively handle events should another major well blowout ever occur.

The Panel has made many recommendations that, if fully implemented, can significantly reduce the number of blowouts. Special emphasis has been placed on critical sour wells. Several of the recommendations relate to a review of drilling equipment, but the primary emphasis has been placed on the need to reduce blowouts caused by human error. The Panel has reviewed the inquiry reports issued earlier this year for the blowout at the SHELL ET AL UNIACKE G-72 well[1], off the east coast of Canada, and the loss of the Ocean Ranger[2] drilling rig. It also has reviewed the previous ERCB report on the blowout of the well, AMOCO PACIFIC BRAZR 7-10-48-12 (7-10 well), which occurred in the same area only 5 years prior to the 13-12 blowout. Each of these three reports indicates that a combination of equipment and human factor causes were responsible for the failures. In each case, the relevant inquiry panel, either directly or indirectly, indicated that the failure probably would not have occurred had appropriate practices been followed, notwithstanding the equipment problems. These conclusions are very similar to those for the 13-12 well.

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[1] Report of Investigation of Events Culminating in a Blowout of Gas and Condensate at Shell Et Al Uniacke G-72.

[2] Royal Commission on the Ocean Ranger Marine Disaster – Report One.

The question, then, is how can human factor problems be significantly reduced in drilling operations? The Panel believes that the most effective way would be to ensure that drilling personnel:

(a) are well trained,

(b) are at all times conscious of potential problems, and ready to deal with them,

(c) are properly supported by technical assistance,

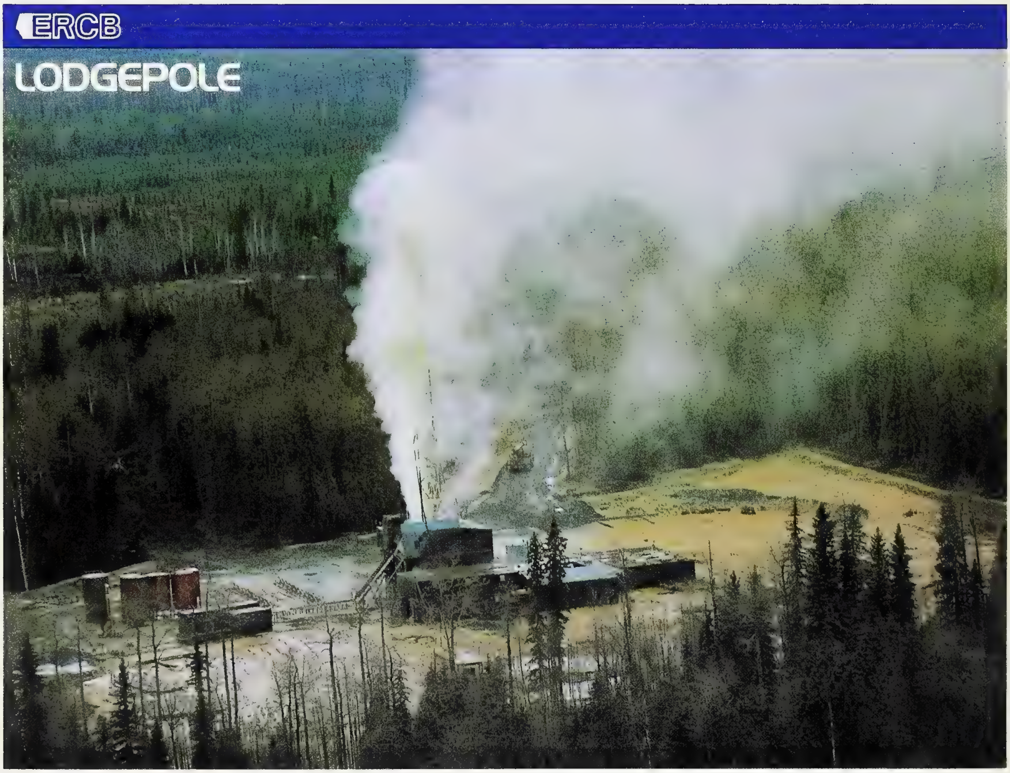
(d) follow a sound and safe drilling plan, and

(e) proceed with operations in a cautious manner, particularly while operating in critical zones.

The primary responsibility for ensuring that these objectives are achieved lies with industry and, in particular, with the company that has been issued a licence to drill. Several of the Panel's recommendations address these issues.

The Panel also believes that the ERCB has a responsibility to test whether these objectives are being achieved, and in that regard believes that the ERCB inspection system should be carefully reviewed to determine how it can be strengthened to minimize human factor problems.

2



The 13-12 blowout prior to the first fire.

Photo credit: W. Wylie, ERCB

2 INTRODUCTION

2.1 Background

The 13-12 well, located in legal subdivision 13 of section 12, township 48, range 12, west of the 5th meridian, 20 km west of the hamlet of Lodgepole, Alberta, blew out of control from 17 October 1982 to 23 December 1982, a total of 67 days. Figure 2.1 shows the location of the blowout[1] relative to Lodgepole and other communities in the general area. The area near the well and especially to the south and west is sparsely populated and almost entirely forest. The hamlets of Cynthia and Lodgepole, approximately 20 km to the northeast and east, have populations of about 70 and 160, respectively. The area between the well and the communities is almost entirely forest with a few residences near, and to the northwest of, Lodgepole. There are a few occupied oil and lumber industry operations within a 20-km radius of the well.

To the east of Lodgepole, the farming population increases and Drayton Valley, with a population of about 5000, is approximately 45 km east of the well. The City of Edmonton, with a population of about 560 000, is 130 km to the east.

On 14 January 1983, the ERCB announced that an inquiry would be held "... to determine the facts surrounding the Lodgepole gas well blowout ...".

2.2 Preparations for the Inquiry

Three public pre-inquiry meetings were held to discuss arrangements for the inquiry, the funding of participants, the terms of reference, and the rules of procedure. The terms of reference, shown in Appendix 2, were issued on 5 May 1983. To ensure adequate notice of the inquiry was given to the public, and to provide an adequate opportunity for the public to participate, the Panel widely publicized the pre-inquiry meetings, the inquiry, and the informal sessions of the inquiry.

The Panel, through the ERCB, funded the participation of several groups, the preparation of several submissions and studies, and funded or provided assistance from legal counsel where such was warranted.

2.3 Procedural Decisions

The inquiry was separated into two phases, the first to deal specifically with the blowout of the 13-12 well, and the second to consider the general question of drilling industry practices in relation to blowout prevention, especially when drilling for sour gas. It was decided to conduct separate registrations of participants for Phase 1 and Phase 2, to hold separate final arguments, and to issue separate reports. The Panel also decided there would be one continuous record for both phases of the inquiry and as a result, evidence filed and heard in Phase 1 would, where appropriate, apply to Phase 2, and vice versa.

2.4 The Inquiry

The Panel consisted of V. Millard, Panel Chairman, and Panel Members, G. J. DeSorcy, P.Eng., F. A. Herbert, M.D., J. W. Markham, M.B., N. A. Strom, P.Eng., and R. S. Weaver, Ph.D.

Messrs. Millard, DeSorcy, and Strom are members of the ERCB. Dr. Herbert is specialized in pulmonary medicine and is an Associate Clinical Professor of Medicine at the University of Alberta. Dr. Markham is experienced in occupational health and is Clinical Professor, Department of Community Health Sciences at the University of Calgary. Dr. Weaver has experience in biophysical and biomedical research and is the Executive Director of the Alberta Environmental Centre in Vegreville.

The formal portion of Phase 1 of the inquiry was held from 1 November 1983 to 15 February 1984. It took place in the town of Drayton Valley except for a sitting on 9 December 1983, which was in Edmonton. Informal sessions of the inquiry were held in Drayton Valley and Edmonton in the evenings of 23 November and 8 December 1983, respectively. Phase 2 was held from 20 February 1984 to 2 March 1984 in Calgary.

2.5 Participants at Phase 1 of the Inquiry

Amoco, the holder of the licence for the well, and Nabors, the drilling contractor for Amoco, were participants in the inquiry.

The government agencies participating were the ERCB staff, several departments of the Alberta Government, the County of Parkland, the Town of Drayton Valley, the Alberta West Central Health Unit, and the RCMP.

Representation of local public concerns was provided by members of PASGEC, a group comprised of 168 citizens living in the area of the blowout. Environmental concerns were represented by the Public Advisory Committee to the Environmental Council of Alberta, and by the Environmental Law Centre. Representation of public health concerns was provided by the Alberta West Central Health Unit, the Health Unit Association of Alberta, and the Canadian Institute of Public Health Inspectors.

The City of Edmonton and the Edmonton Board of Health were represented, as were a group of respiratory patients from the Aberhart Centre in Edmonton, the Edmonton Area Respiratory Patients.

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[1] See Appendix 1, Glossary of Terms for definition of technical or unusual terms used in the report.

Mr. C. Sams participated to represent concerns regarding the safety of workers in the drilling industry.

A total of 144 persons representing 21 organizations, and one private individual, participated in the formal portion of Phase 1 of the inquiry. In addition, 17 members of the public appeared on their own behalf at the informal sessions in Drayton Valley and Edmonton. Persons and organizations appearing are listed in Appendix 3. A summary of the views of each participant is provided in Appendix 4.

The Panel appreciates the efforts and contributions made by all participants at the inquiry. They provided the inquiry, and therefore the public, with an in-depth review of the blowout, its cause, and its impacts.

As a result of the varied and comprehensive participation, the disclosure of documents, evidence under oath, and the right of cross-examination afforded to all participants, the Panel was satisfied at the conclusion of the inquiry that it had heard and had available to it all evidence necessary for it to make the findings of fact and recommendations in this report. However, to clarify the evidence, the Panel requested and received additional data, after the inquiry, from Amoco and AE with respect to air monitoring, and from Amoco with respect to mud volumes.

2.6 Phase 1 and Phase 2 Reports

The Panel concluded that several recommendations made by participants at Phase 2 could reduce the possibility of a blowout. Since drilling in the Province is continuing, the Panel decided that the recommendations should be implemented as quickly as possible. It therefore decided to issue the Phase 2 report first and Decision D 84-5 was issued in April 1984. A copy of the Phase 2 report is attached as Appendix 5.

This report pertains to Phase 1 of the inquiry, and additionally reports, in section 14, on the progress to date resulting from the recommendations in the Phase 2 report.

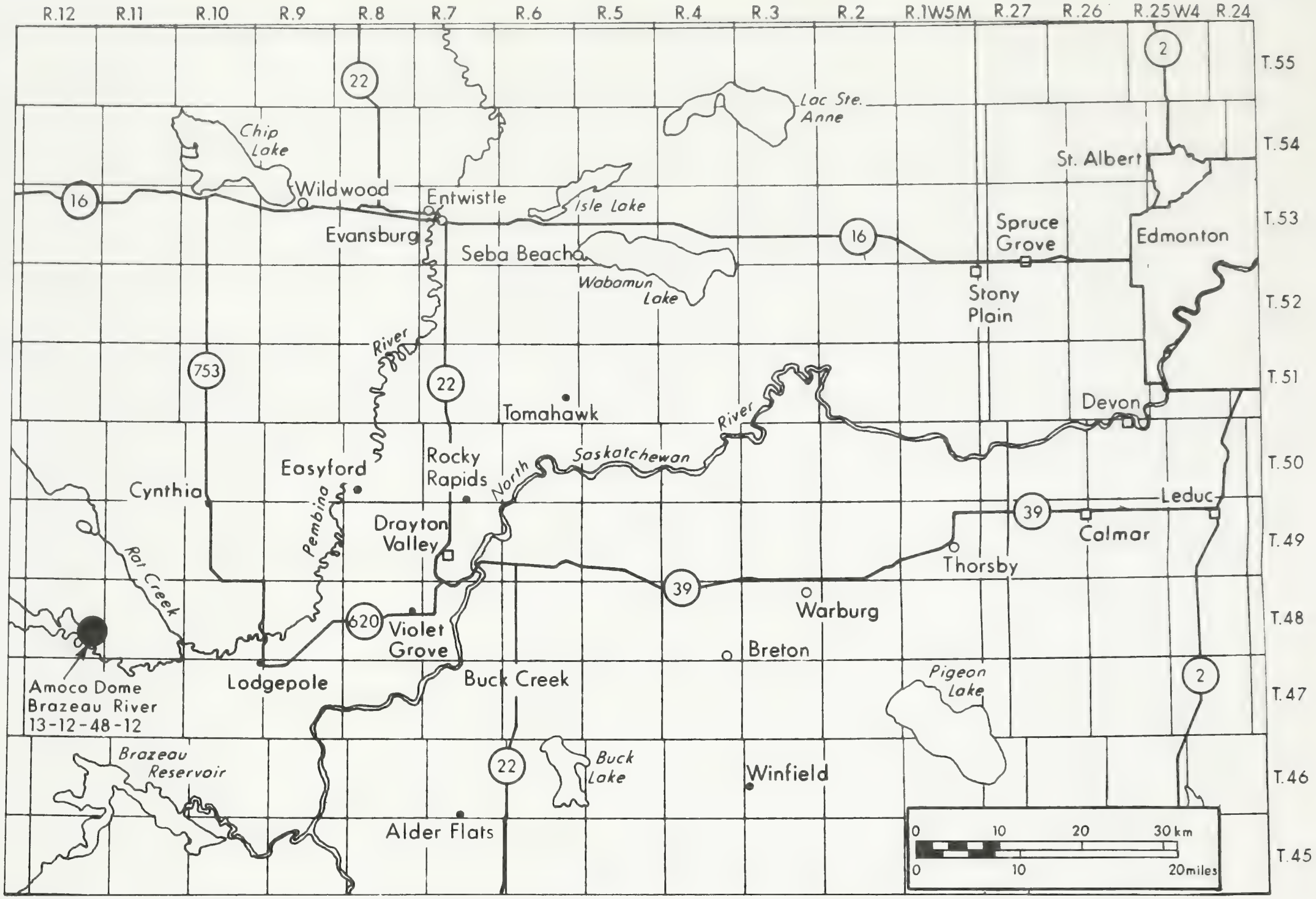
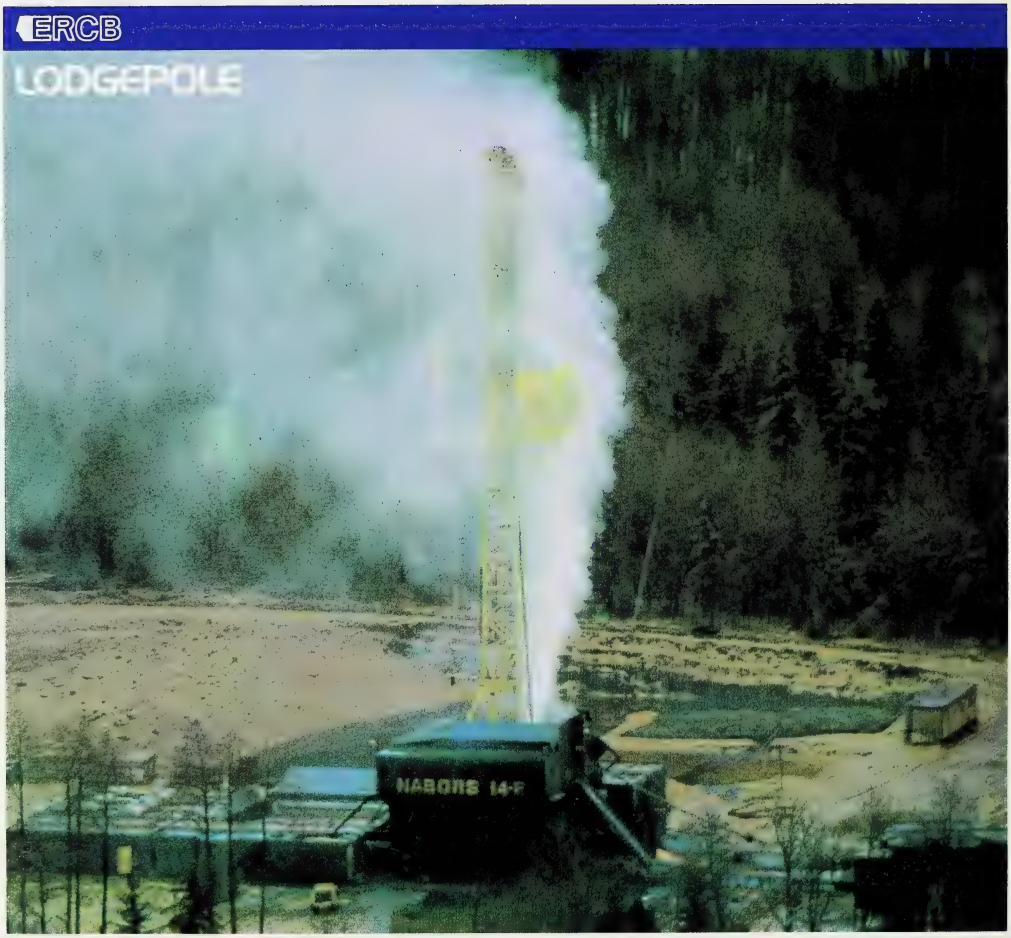


FIGURE 2.1 LODGEPOLE - EDMONTON AREA

3



Close-up of the Nabors rig prior to the first fire.

Photo credit: W. Wylie, ERCB

3 A BRIEF REVIEW OF THE ON-SITE ACTIVITIES PRIOR TO AND DURING THE BLOWOUT

3.1 Introduction

This section has been written to give the reader an overview of the events at the well site prior to and during the blowout. An analysis of these events is provided in sections 5 and 6. Figure 3.1 is a corresponding chronology of these events and subsequent related developments.

The 13-12 well is located in the Brazeau Field and was drilled to test a Nisku pinnacle reef that had been identified through seismic work done in the area.

The first well to penetrate one of these prolific reefs was drilled in January 1977. It penetrated what is now known as the Pembina Nisku A Pool at a depth of 3000 m. Since then, over 50 geological structures have been identified and drilled in the general area, known as the West Pembina Nisku play. Reef structures in the vicinity of the 13-12 well fall into two distinct categories:

(1) the pinnacle reef structure, which ranges from a quarter section to more than a section in area and usually contains oil or oil with an associated gas cap generally having a low H_2S content, and

(2) the Meekwap bank, which is a large continuous carbonate bank with a series of coalescing reefs along its fringe. The fringing reefs usually contain gaseous (no oil) hydrocarbons rich in natural gas liquids and H_2S.

On the basis of its interpretation of the seismic data, Amoco expected its 13-12 well to terminate in a pinnacle reef, near to but structurally separated from the bank. This is illustrated in Figure 3.2. Amoco thus expected to find a sweet oil-bearing formation. However, the possibility of encountering sour gas and condensate was recognized and precautions for that eventuality were included in the well program.

3.2 Drilling the Well

Amoco's seismic interpretation required the bottom-hole location of the well to be in Lsd 11 of 12, however, the surface vertically above that location was in an environmentally sensitive area near the Pembina River. To reduce environmental impacts, Alberta Energy and Natural Resources (E&NR) required Amoco to move the surface location to Lsd 13-12. This made it necessary for the well to be directionally drilled.

The 13-12 well was spudded 10 August 1982, using the Nabors 14E drilling rig. Drilling of the surface hole took 3 days, at which time surface casing was run to 330 m and cemented to surface.

The drilling program called for the use of oil-based mud until the intermediate casing was set and a changeover to a water-based mud system for drilling below the intermediate casing. The water-based mud system was to maintain a high pH and contain an H_2S scavenger, iron oxide, to counteract any H_2S that might enter the wellbore.

Drilling continued without significant incident until the intermediate casing depth was reached on 6 October. Over the next 3 days, casing was run to a depth of 3002 m and cemented to at least 120 m above the base of the Belly River. The oil-based mud system was then displaced to a water-based mud as planned. The blowout preventer (BOP) stack and choke manifold were pressure tested to ERCB requirements, a blowout drill was conducted by both the evening and day crews, and on 13 October, the intermediate casing shoe was drilled out.

Figure 3.3 summarizes the drilling activities from 13:00 on 13 October to the time of the blowout as compiled from the evidence and exhibits at the inquiry, particularly Exhibits No. 66 and 66.1.

On 15 October, coring operations began at a depth of 3051 m and mud containing iron oxide was weighted up to 1165 kilograms per cubic metre (kg/m^3) in preparation for the coring program.

3.3 Trouble Begins

The coring program involved using a 20-m-long core barrel assembly with intentions of obtaining 18-m-length cores. Although cores No. 1 and 2 were cut and retrieved with relatively little incident, they had to be broken off short of the 18-m objective because they jammed in the core barrel. The recovered cores were noted to be vugular, ie, highly porous, containing large holes (like swiss cheese), and smelled of H_2S. On 16 October at 16:00 the trip into the hole for core No. 3 began.

Mud weight at the commencement of core No. 3 was 1175 kg/m^3 including 17.5 kg/m^3 of iron oxide. Because of the shortened core length experienced with cores No. 1 and 2, Amoco decided to install a 4-m pup joint to provide for cutting at least 12 m of core No. 3 before making a connection. Coring continued normally from 3063 m but at 3066 m, at 22:50 on 16 October, a Nabors roughneck noticed mud splashing intermittently from the flow nipple. The crew was immediately alerted, circulation was stopped, and a standard flow check was conducted which showed that no flow was occurring. However, the gas count on the mud logger increased sharply and a strong H_2S odour became apparent. The annular preventer was closed to obtain shut-in pressure readings. The shut-in drill pipe and casing pressure gauges both read zero.

FIGURE 3.1 **CHRONOLOGY OF WELL-SITE RELATED ACTIVITIES PRIOR TO, DURING, AND SUBSEQUENT TO THE BLOWOUT OF AMOCO DOME BRAZEAU RIVER 13-12-48-12**

1981	Oct	Potential Lease Scouted	Planning and Drilling Phase
	Dec	Well Planning Initiated	
1982	Feb	Right of Entry Approved	
	Jul	Drilling Program Formulated	
	9 Aug	Application for a Well Licence	
	10 Aug	Well Licence Issued Well Spudded by Nabors 14E Rig	
	13 Aug	Surface Casing Set	
	10 Oct	Intermediate Casing Set	
	15 Oct	Coring Operations Began	
	17 Oct	Blowout Occurred at 14:30 Emergency Task Forces Mobilized	Loss of Control Phase
	18 Oct	NOTAM (Notice to Airmen) Issued	Well Control Attempts Phase
	19 Oct	ERCB Fire Hazard Order # FH 82-1 Issued Wild Well Control Inc. Personnel Arrived on Location Control Plan A Developed	
	20 Oct	Control Plan B Developed as Contingency Initiated Plans for Relief Well	
	27 Oct	Control Plan A Abandoned Control Plan B Implemented	
	1 Nov	Control Plan B Failed Well Accidentally Ignited	
	4 Nov	Verbal Approval for Relief Well Site	
	8 Nov	Hi-Tower Rig on Standby for Relief Hole	
	14 Nov	Well Fire Extinguished	
	15 Nov	Ministry of Transport Issued Air Space Restriction Order	
	16 Nov	Control Plan C Implemented Accident Occurred – 2 Fatalities	
	25 Nov	Well Accidentally Reignited	
	1 Dec	Control Plan C Abandoned Wild Well Control Inc. Released Boots and Coots Inc. Personnel Arrived	
	4 Dec	Final Control Plan Initiated	
	23 Dec	Well Controlled	Well Controlled
	31 Dec	Environmental Clean-up Initiated	
1983	13 Jan	Hi-Tower 1E Drilling Rig Moved on Location	Well Completion Phase
	24 Feb	Fishing Operations Completed	
	27 Feb	Finished Drilling	
	2 Mar	Production Casing Set	
	4 Mar	Wellhead Installed	
	1 Nov	Phase 1 Commenced	Inquiry
1984	15 Feb	Phase 1 Completed	
	20 Feb	Phase 2 Commenced	
	2 Mar	Phase 2 Completed	
	26 Apr	Phase 2 Decision Report Released	
	18 Dec	Phase 1 Decision Report Released	

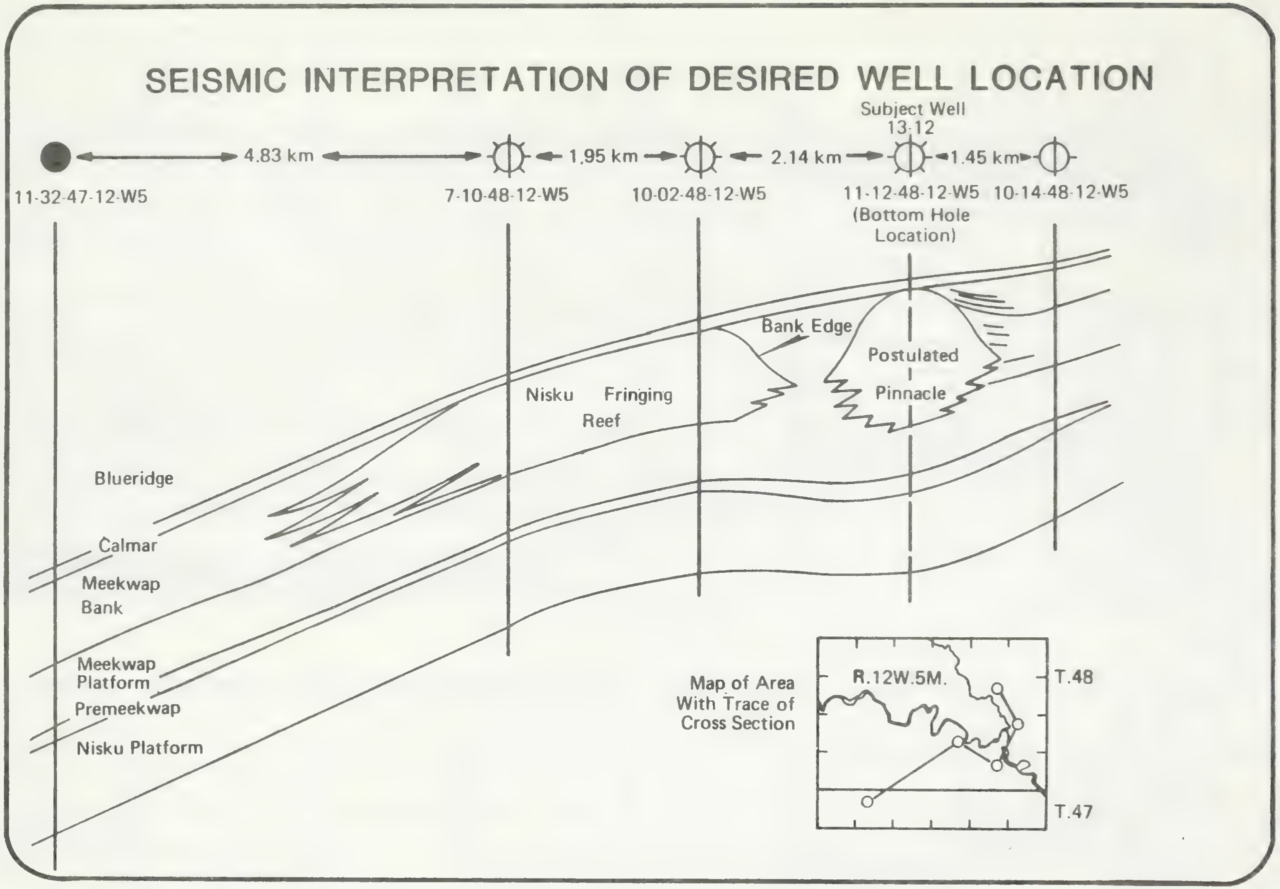


FIGURE 3.2 AMOCO'S SEISMIC INTERPRETATION OF DESIRED WELL LOCATION.
Reproduced from Exhibit No.66.

FIGURE 3.3 DRILLING SUMMARY FROM DRILLING OUT INTERMEDIATE CASING UNTIL BLOWOUT

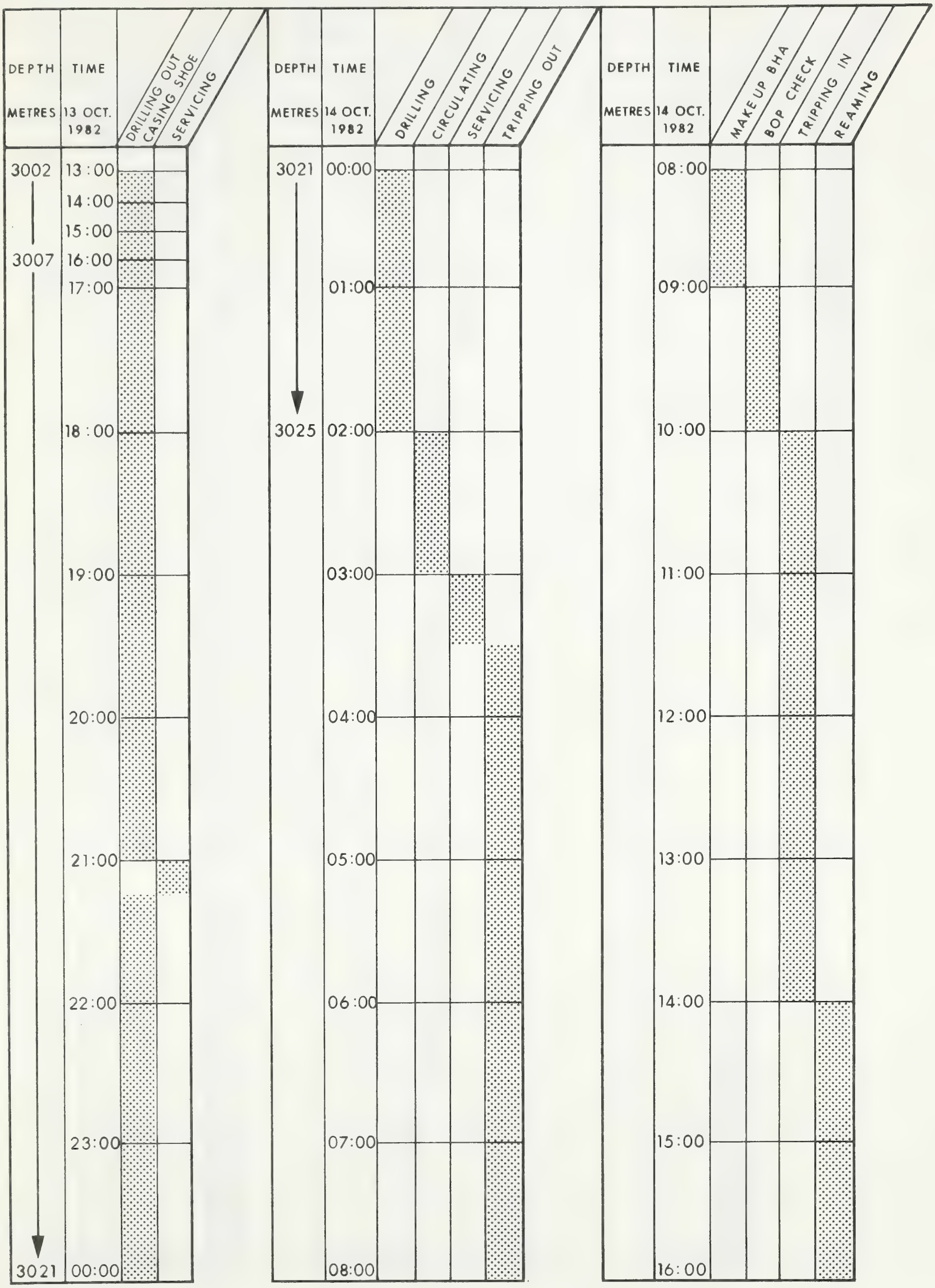


FIGURE 3.3 CONT'D.

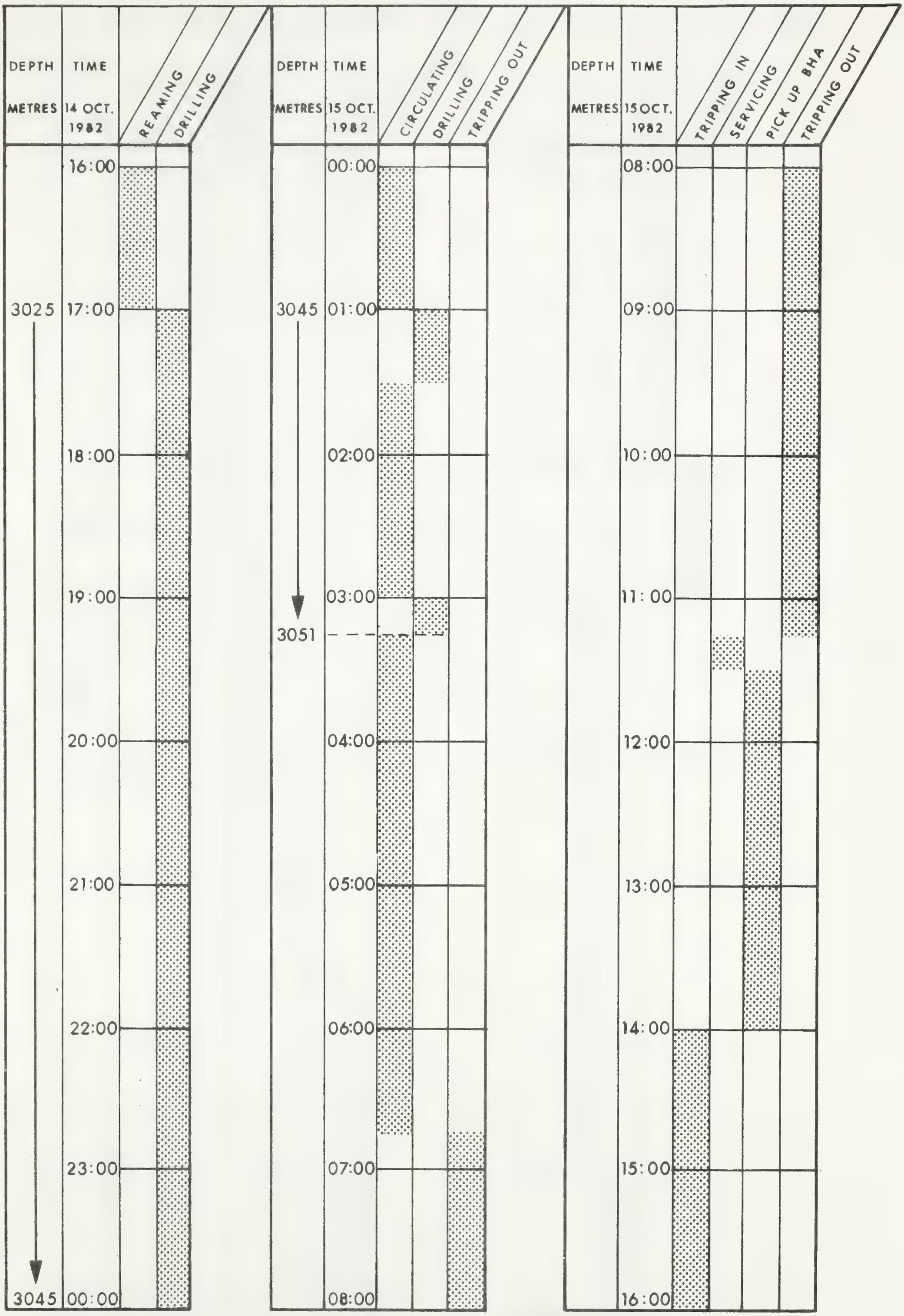


FIGURE 3.3 CONT'D.

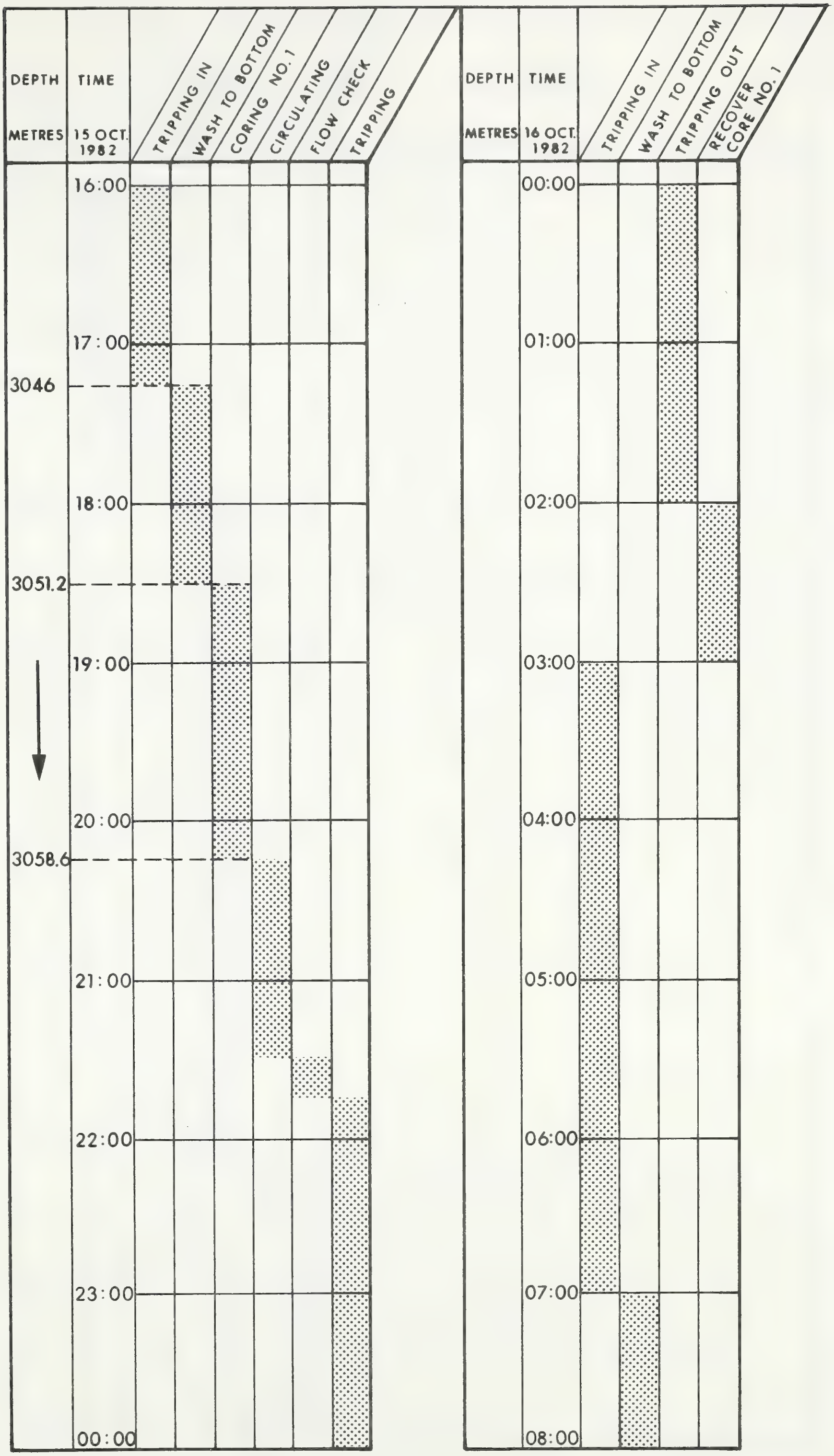
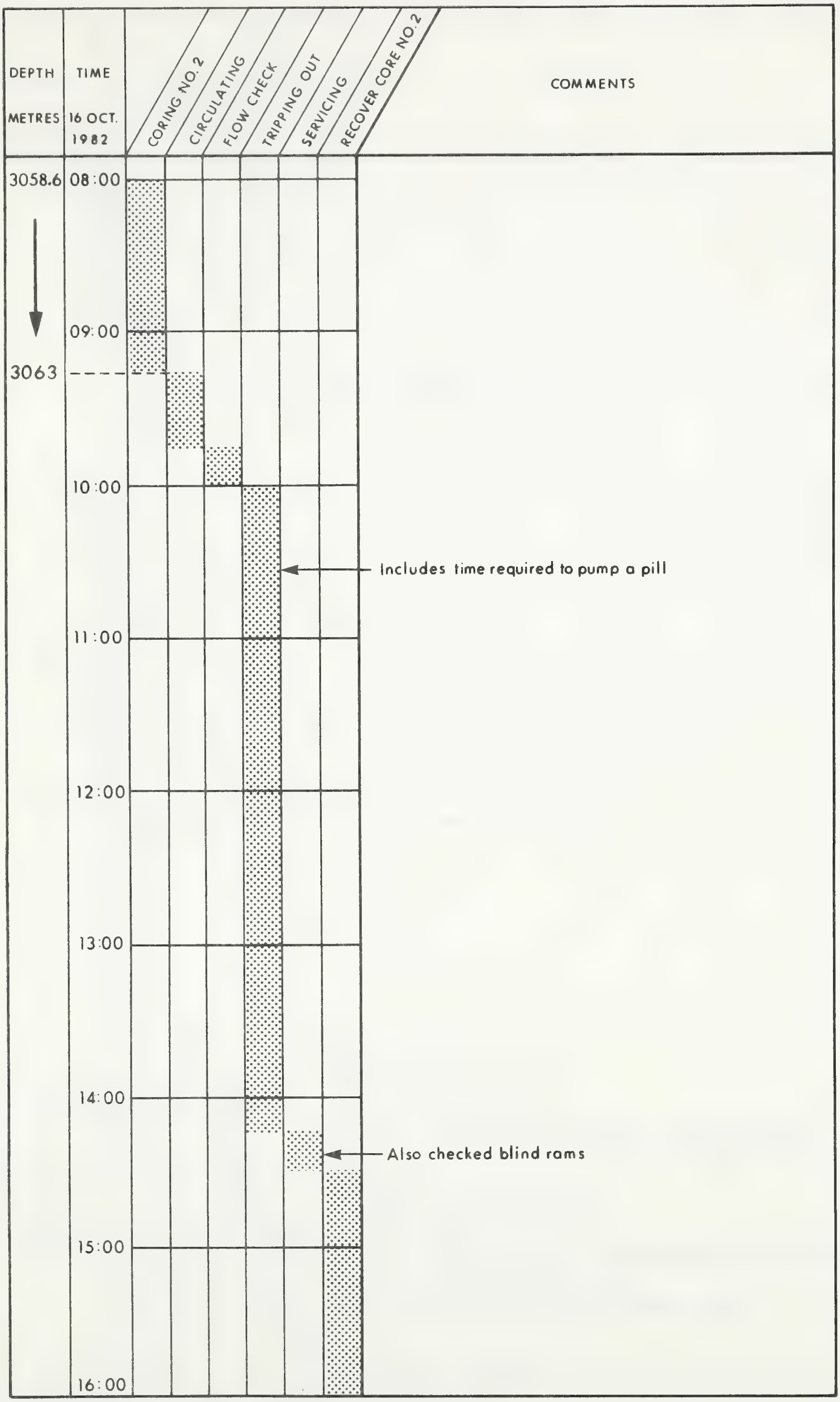


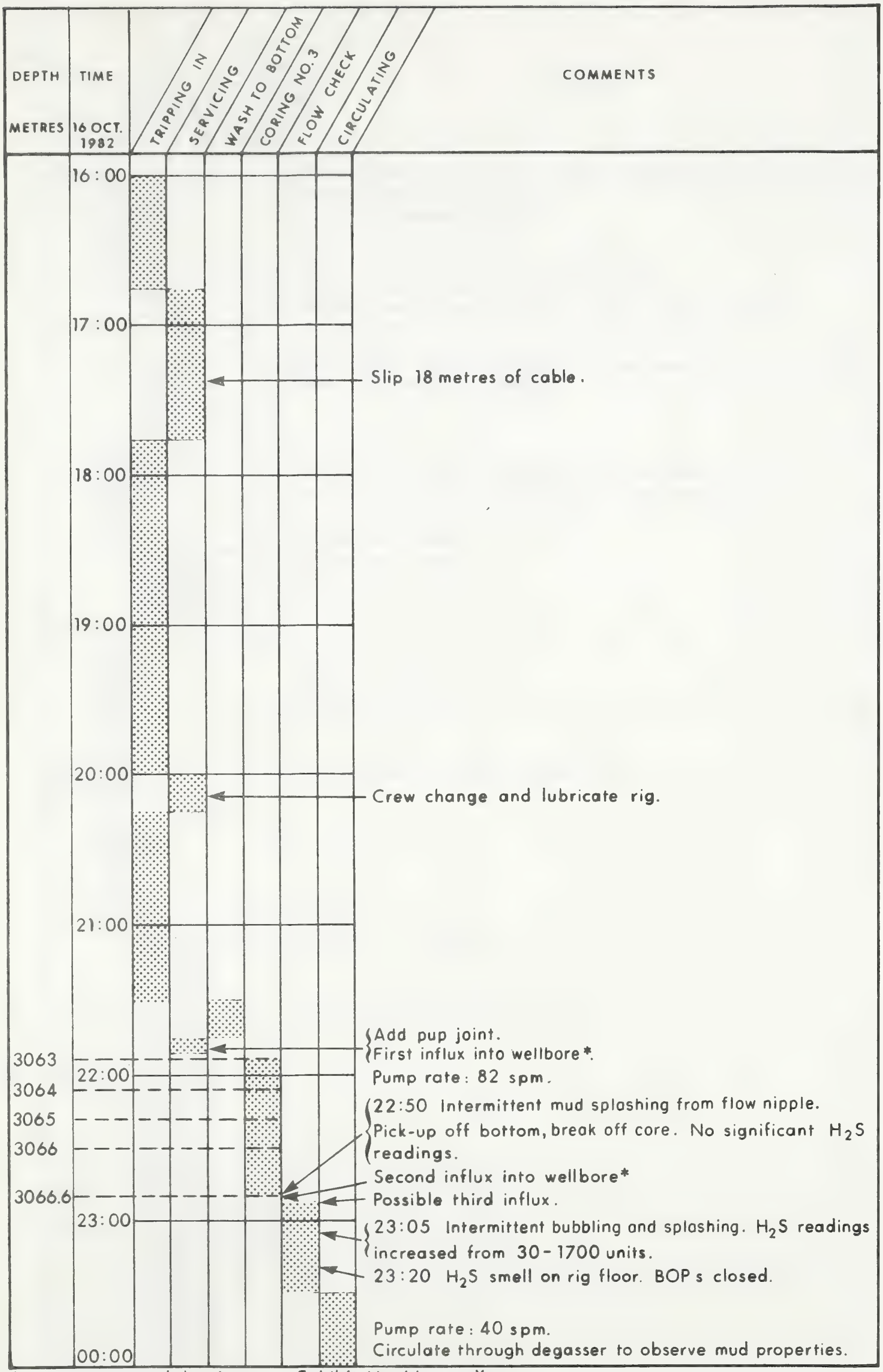
FIGURE 3.3 CONT'D.



Includes time required to pump a pill

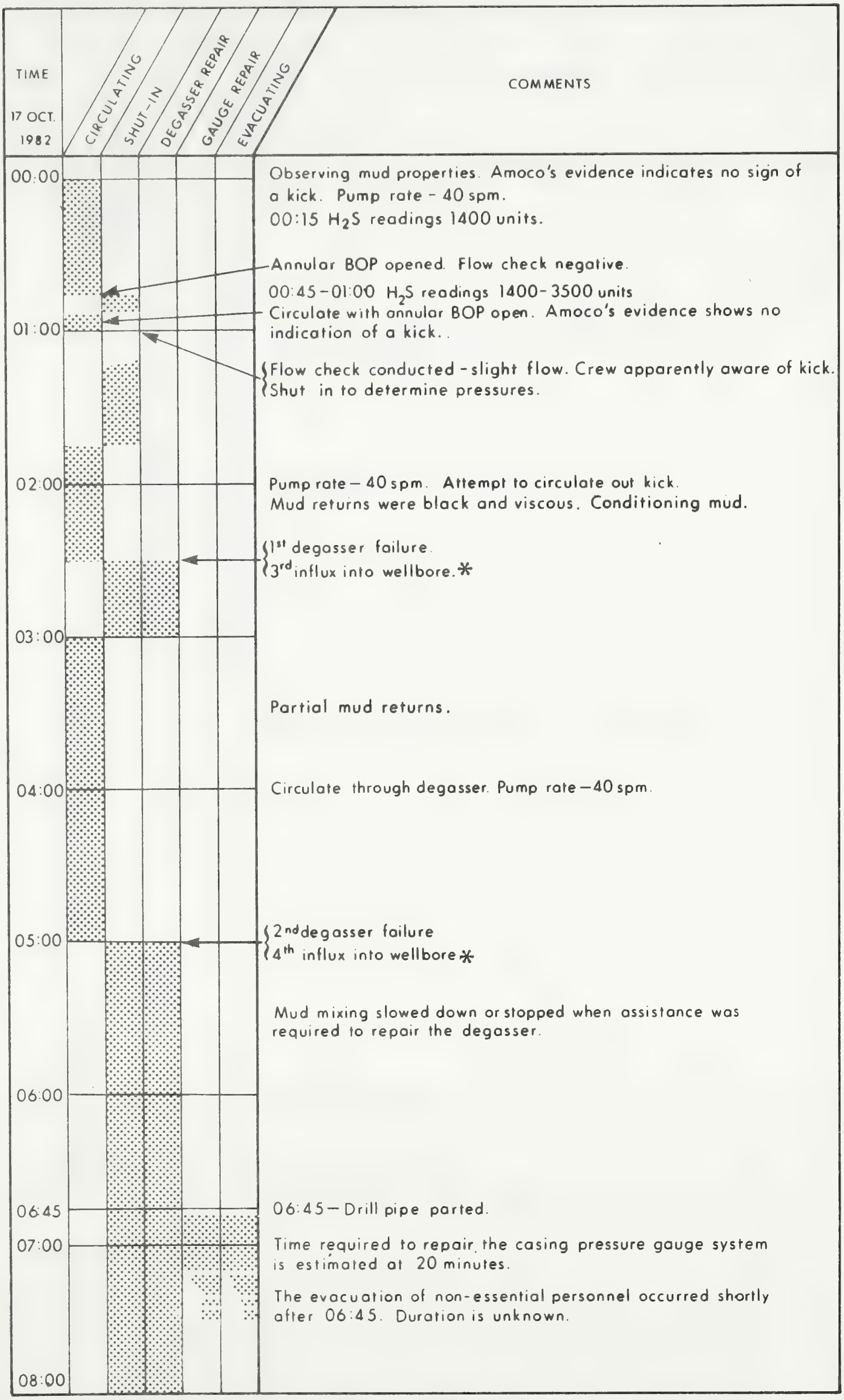
Also checked blind rams

FIGURE 3.3 CONT'D.



*As hypothesized by Amoco - Exhibit No. 66 part X.

FIGURE 3.3 CONT'D.



Observing mud properties. Amoco's evidence indicates no sign of a kick. Pump rate - 40 spm.

00:15 H_2S readings 1400 units.

Annular BOP opened. Flow check negative.

00:45 - 01:00 H_2S readings 1400 - 3500 units

Circulate with annular BOP open. Amoco's evidence shows no indication of a kick..

Flow check conducted - slight flow. Crew apparently aware of kick.
Shut in to determine pressures.

Pump rate — 40 spm. Attempt to circulate out kick.
Mud returns were black and viscous. Conditioning mud.

1st degasser failure.
3rd influx into wellbore.*

Partial mud returns.

Circulate through degasser. Pump rate — 40 spm.

2nd degasser failure
4th influx into wellbore*

Mud mixing slowed down or stopped when assistance was required to repair the degasser.

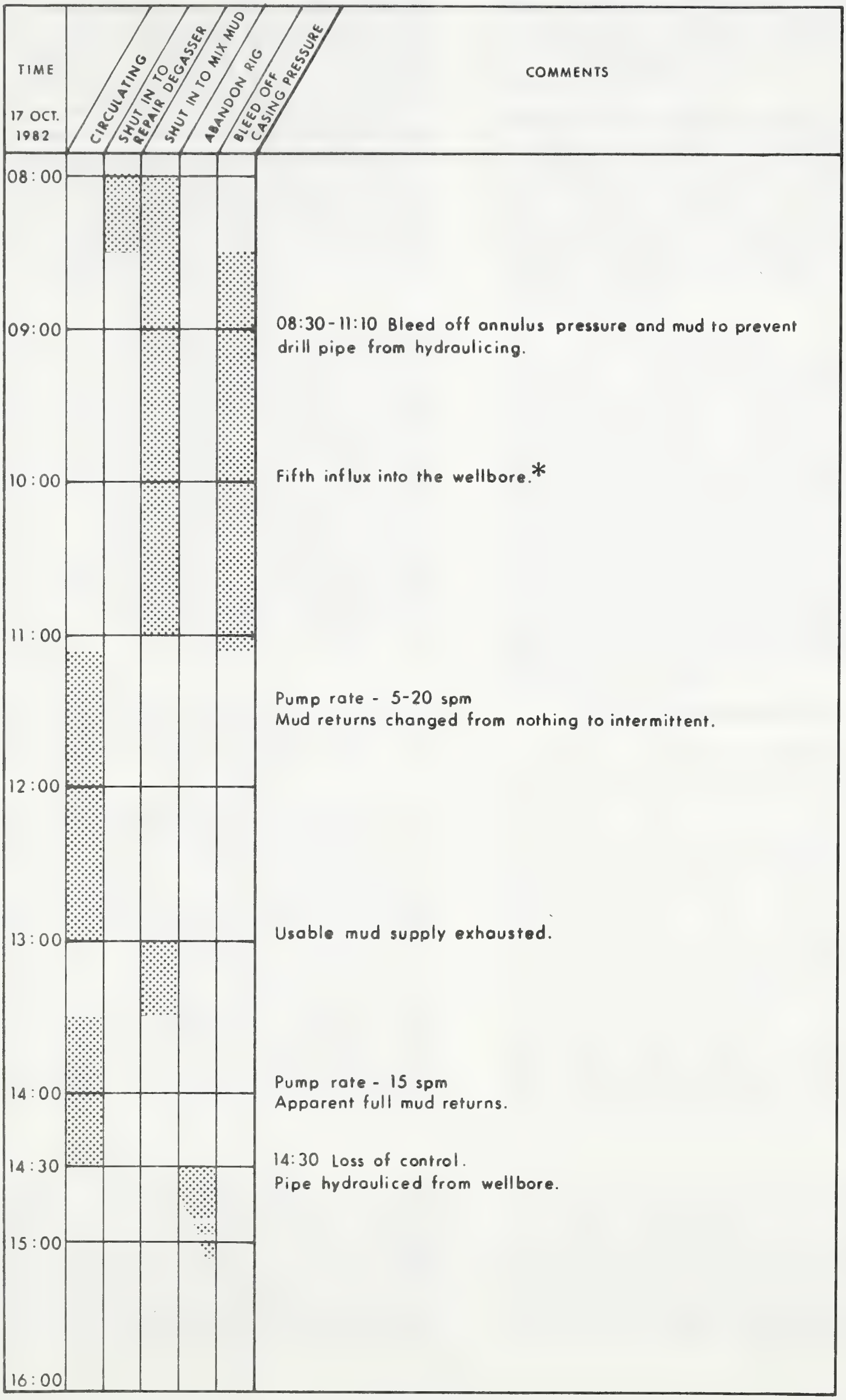
06:45 — Drill pipe parted.

Time required to repair the casing pressure gauge system is estimated at 20 minutes.

The evacuation of non-essential personnel occurred shortly after 06:45. Duration is unknown.

* As hypothesized by Amoco — Exhibit No. 66 part X.

FIGURE 3.3 CONT'D.



08:30-11:10 Bleed off annulus pressure and mud to prevent drill pipe from hydraulicing.

Fifth influx into the wellbore.*

Pump rate - 5-20 spm
Mud returns changed from nothing to intermittent.

Usable mud supply exhausted.

Pump rate - 15 spm
Apparent full mud returns.

14:30 Loss of control.
Pipe hydrauliced from wellbore.

*As hypothesized by Amoco - Exhibit No. 66 part X.

At 23:30, with the annular preventer closed, circulation was resumed through the choke manifold and the degasser. Circulation pressure was 2000 kilopascals (kPa). In the early hours of 17 October, circulation was stopped and a flow check again indicated no flow. Conventional circulation, with mud returns direct to the mud tank, was re-established. However, in a short period of time, gas readings increased sharply. A flow check indicated a slight mud flow so the well was shut in to observe pressures. The drill pipe pressure was 2000 kPa and the casing pressure gauge read zero. At 01:45 it was assumed that the casing pressure gauges at both the driller's panel and choke manifold were not functioning.

Circulation through the choke manifold and degasser was resumed at 01:45 until, at approximately 02:30, the degasser failed when the float jammed in its seat. The degasser was repaired by 03:00 and circulation resumed until 05:00 when another surge of mud and gas erupted through the degasser, jamming the float down, puncturing it, and wedging it into its seat. Amoco estimated that 30 m^3 of mud had been lost into the flare pit and on the ground as a result of the failure. At 06:45 the drill pipe suddenly parted. To prevent the remaining pipe from rising out of the hole, the upper pipe rams were immediately closed. The faulty casing pressure instruments were repaired and the casing pressure was found to be 10 500 kPa.

After the drill pipe parted, all non-essential personnel were evacuated from the lease and additional sour gas detection and breathing apparatus was ordered to the location.

By about 08:30 in the morning of 17 October, the degasser had been repaired and by 11:00, mud had been reconditioned. Mud weight had been increased to 1440 kg/m^3 and more iron oxide added. Circulation was resumed. Casing pressure was reduced from 9200 to 7000 kPa through the choke system on the manifold. After circulating for an hour, intermittent mud returns were restored and maintained until, at 13:00, the weighted mud volumes in the suction tank were used up. The well was again shut in to mix a further 25 m^3 of 1350 kg/m^3 mud. During the 30-minute shut-in period, drill pipe and casing pressure remained static at 10 000 kPa. Circulation was resumed and by 14:10 full mud returns were obtained.

3.4 The Blowout

At 14:30, the drill pipe started to hydraulic out of the hole. The driller immediately engaged the draw works and attempted to raise the block and hook ahead of the rising kelly and drill pipe. The drill pipe rose faster, causing the kelly bales to hit the hook latch and the bales fell out of the hook. The upward travel of the drill pipe was arrested when a tool joint lodged against the closed pipe rams. The kelly, now unsupported, fell through the "V" doors on the rig floor bending the drill pipe. The kelly hose broke off at the gooseneck on the kelly swivel and mud and gas began to blow out of the gooseneck. The well was now out of control.

Estimates of the emissions at the time of the inquiry were 1.4 million (10^6) m^3 of gas[1], or 50 million cubic feet per day, containing 23 to 25 per cent H_2S, and 750 m^3 of condensate per 10^6 m^3 of gas or 133 barrels of condensate per million cubic feet of gas. However, during the blowout itself, estimates varied but were somewhat less than the 1.4 x 10^6 m^3, and considerably less with respect to estimates of H_2S.

3.5 Emergency Measures

At 14:30 on 17 October with the well out of control, Amoco initiated action under its "Major Wellsite Incident Response Plan". Key Amoco personnel were alerted and they implemented actions necessary to respond to the blowout. Additional safety personnel, breathing apparatus, paramedics, ambulances, helicopters, and fire protection equipment were contracted for dispatch to the site. Continuous H_2S monitoring equipment was ordered for both on-site and off-site monitoring. Special tools for blowout control were ordered and a control specialist, Wild Well Control Inc. (Wild Well) of Houston, Texas was engaged. Shortly afterwards, the area was closed to all unauthorized personnel by ERCB order.

3.6 Well Control Attempts Begin

On 19 October, the crew of well-control specialists from Wild Well arrived on location. The bent drill pipe protruding above the drilling floor had broken at the bend and fallen away, leaving a 0.3-m stub of drill pipe protruding above the rotary table. Faced with this situation, two alternative control plans were developed. Plan A involved the fabrication of a blind ram BOP on top of a long valved spool. This assembly would be stripped down over the drill pipe stub and attached to the top of the annular preventer. The mud lines would then be hooked to the spool, the blind ram BOP would be closed, and mud would be pumped into the well. On 27 October, after some preliminary preparation, it was determined that the opening in the automatic pipe stripper below the rotary table was too small to allow the passage of the kill spool, the pipe stripper could not be removed because of the drill pipe, and Plan A was discarded.

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[1] The flow rate of the well is unknown. At the time of the inquiry, it was estimated at 1.4 x 10^6 m^3 of gas per day. During the blowout, the flow rate would vary depending on the size of the opening at the surface which changed as the condition of the well changed. The well has been partially tested since that time and indications are that the flow could be substantially higher.

Plan B consisted of opening the BOPs to allow the drill pipe to drop down the hole and then closing the blind rams. Amoco recognized that the drill pipe might be blown out of the hole rather than dropping as planned. After completing some related calculations and assessing the alternatives, Amoco decided to proceed with Plan B.

On 1 November at 14:07, after a previous attempt in the morning had failed, the BOPs were successfully opened. The drill pipe immediately shot out of the hole, striking the monkey board in the derrick and, in a few seconds, the entire location was engulfed in flames. Very shortly afterwards, the rig derrick collapsed.

The next several days were spent cleaning away debris. In the interim, a relief well site was constructed and the possibility of drilling a relief well was re-examined and rejected on the basis of potential risk to the drilling crew and the expectation of an early top kill of the 13-12 well. Nevertheless, a suitable drilling rig was placed on standby and a drilling program was designed.

On 14 November, the well fire was extinguished through the use of explosives and Plan C was attempted. It entailed the removal of the existing intermediate casing spool and installing a new spool and BOP control stack.

On 16 November, a large crane was employed to lift the BOP assembly over the wellhead. During this attempt, an accident occurred which resulted in the death of two Wild Well employees who were overcome by H_2S.

Wind direction, low wind velocities, and ground inversions continued to hamper further activity from 17 to 25 November. Suddenly, at 12:53 on 25 November, a fire started some 60 m southwest of the well and, within minutes, the lease and well were again on fire. It was later determined that the probable cause of ignition was a muskeg fire, more than a metre underground, that had gone undetected.

3.7 Establishing Control of the Well

After the condensate on the lease had been burned, it was discovered that the extreme heat had damaged the well casing, making its integrity suspect. At this time, Amoco had been advised by the ERCB it could extinguish the fire and have one more attempt to control the well prior to drilling a relief well. Amoco chose to cap the well while on fire, a procedure which had only been successfully completed six times, and on much smaller wells. Wild Well declined to attempt this procedure and, on 1 December, the well control firm of Boots and Coots Inc. was contracted to undertake capping the well while on fire. The procedure was to consist of cutting off a short section of the surface and intermediate casings to remove the old surface casing bowl along with a short top section of damaged surface casing, and then welding on a new bowl. The team would then strip on a spool and blind ram BOP, close in the flow, and pump mud down the hole until the well was controlled.

Cutting off the casing bowl commenced on 4 December and a new bowl was stripped over the intermediate casing stub and welded in place on 16 December. Several days of delay were then experienced due to equipment malfunction as well as unfavourable weather conditions. Finally, on 23 December 1982, the BOP stack was stripped over the intermediate casing stub and bolted to the casing bowl. Flare and kill lines were connected. Valves to the flare line were opened and the blind rams were closed. The flare valves were closed, the mud pumps were started, and weighted kill mud was pumped into the well. For all intents and purposes, the well had now been controlled.

Over the next 5 days, the operations of pumping mud into the well and bleeding off pressure were alternately applied until, after pumping in a total volume of 96 m^3 of mud, the well stabilized. This permitted entry into the wellbore and finally, on 28 December, utilizing a special riser and lubricator, a packer was set in the intermediate casing which secured the well and permitted a future change-out of the BOP assembly. The drama had ended.

In Appendix 6, the Panel has included a series of photographs of various events in the blowout incident. Not all of the photographs were submitted at the inquiry, but the Panel believes the reader may benefit from them being included in the report.

4

Lodgepole Inquiry in Drayton Valley, Alberta.

Photo credit: G. Brosinsky, ERCB

4 ISSUES

Phase 1 of the inquiry extended over a period of 47 days, 245 exhibits were filed, and the transcripts of the evidence required over 9700 pages.

The evidence presented covered many aspects of the blowout and its effects, some of which were of a critical nature with respect to the impact of the event while others were of lesser importance.

After reviewing the evidence from the inquiry and the positions presented by the participants, and having in mind the terms of reference for the inquiry, the Panel considers the most important issues to be as follows:

(a) Cause of the Blowout and Adequacy of Actions Taken by Amoco to Prevent it,

(b) Well Control Activities and the Adequacy of Actions by Amoco and Others,

(c) Hazard to Human Health,

(d) Impact on the Environment and on Personal Property,

(e) Communication and Co-ordination,

(f) Adequacy of ERCB Responses Following the Blowout, and Its Regulations, Policy, and Procedure, and

(g) Adequacy of the Government Departments' Responses following the Blowout, and Their Regulations, Policy, and Procedure.

The Panel has addressed, in detail, what it considers to be the more critical of these areas and has dealt more generally with those of lesser impact. In all cases where it appeared to the Panel that recommendations for change were necessary, it has made such recommendations.

The seven issues listed above are discussed in sections 5 to 11. Section 12 summarizes the Panel's findings and recommendations, and section 13 attempts to analyse the significance those recommendations may have had on the 13-12 well, had they been in effect. Section 14 reports on progress to date respecting matters dealt with in the Phase 2 report.

5

Nabors 14-E rig in the Alberta Foothills. (This is not the 13-12 location)

5 THE CAUSE OF THE BLOWOUT AND ADEQUACY OF ACTIONS TAKEN BY AMOCO TO PREVENT IT

5.1 Introduction

One of the Panel's primary objectives in the inquiry has been the identification and assessment of the factors contributing to the blowout of the 13-12 well. A correct understanding of those events is necessary to judge the appropriateness of the actions taken, and to plan changes in procedure or equipment which could reduce the possibility of future blowouts.

In this section, the Panel examines the factors which it believes contributed to the blowout, and whether Amoco took reasonable precautions with respect to each of the factors. In so doing, the Panel recognizes it is focusing attention on those facets where problems occurred, and that there were many other areas where actions by Amoco, its staff, and its contractors were proper and adequate. In making this assessment, the Panel has endeavoured to evaluate the suitability of the actions on the basis of information that was available to the wellsite personnel at the time the actions were taken.

After reaching conclusions on Amoco's actions, the Panel at various places identifies drilling practices which, as a result of this particular experience, should be further investigated by the Blowout Prevention Review Committee (BPRC)[1] in order to overcome the noted deficiences.

The Panel has minimized specific references to Nabors and other suppliers of services and materials for the 13-12 well. These are regarded by the Panel as agents of Amoco and acting according to Amoco's direction and control.

5.2 A General Well Control Plan

A general well control plan, as referred to in this report, is a strategy which establishes the basic principles which must be followed to ensure that a well will not blow out during drilling, completion, or production operations. It rarely exists as a single document but, rather, is those portions of the drilling plan or program, special instruction bulletins (some posted in the doghouse), company procedure manuals, and other books, manuals, and written and verbal instructions that taken together aim to accomplish the objectives of a general well control plan.

In this section, the Panel focuses attention on the Amoco plan for the drilling of the 13-12 well.

Amoco indicated that it expected the 13-12 well to encounter sweet oil, but that the control plan definitely recognized and accounted for the possibility of sour gas. The Panel, as a result of reviewing the evidence, accepts that such was the case and does not believe the expectation for sweet oil played a direct role in the cause of the blowout. However, it may have influenced planning for the well and may have led to less caution in the drilling operations than might have been the case if the well was being drilled specifically for sour gas.

The drilling fluid (mud) system has a dominant position in the general well control plan for any well. The plan requires that the hydrostatic pressure in the wellbore be greater than the formation pressure. Hydrostatic pressure depends on the height of the column of drilling mud and the density of the mud. A reduction in either or both of these will reduce the pressure that results from the column or head of drilling mud. If the hydrostatic pressure is too low, a state of underbalance exists and fluids from the formation, such as gas, may flow into the wellbore. Unless this flow is properly controlled, a blowout will result. On the other hand, if the hydrostatic pressure is too great and a state of excessive overbalance exists, the drilling mud may flow into the formation. This is referred to as "lost circulation" and will result in a loss of hydrostatic pressure which can also lead to a blowout.

Operating practices can also influence the effective pressure exerted by the drilling mud column on a porous formation. The action of the mud pump working to circulate the mud down the drill pipe and up the annulus will add dynamic pressure to the mud column. When tripping drill pipe into the well, a temporary increase in pressure, or surge pressure, can be generated if the drill pipe is lowered too fast. A reverse condition, a reduction in pressure or swabbing effect, may occur if the drill-pipe assembly is hoisted too rapidly during tripping out operations.

In developing a drilling program, an operator must therefore consider formation pressures encountered at other wells in the general vicinity of the well being planned for and select a drilling mud density which will ensure a modest overbalance. To ensure that neither a state of underbalance nor of excessive overbalance develops as the well is drilled, close attention must be given to:

(a) mud density,

(b) any contamination of the drilling mud that will change its effective density, such as by drill cuttings (increase) or by air introduced during tripping (decrease),

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[1] The BPRC was established as a consequence of the decisions made by the Panel following Phase 2 of the inquiry. The committee is made up of representatives of industry and the ERCB, and has been asked to investigate a large number of blowout related questions. Recommendations are to be developed for consideration by the public and government, and for decision by the ERCB.

(c) maintaining a full mud column,

(d) the rate of lowering the drill pipe,

(e) the rate of hoisting the drill pipe, and

(f) pumping rate and pressure.

Should the hydrostatic pressure from the mud column prove to be insufficient, and as a consequence, formation fluids such as gas enter the wellbore, a kick condition would exist. Procedures have been developed such that those fluids may be controlled within the wellbore using the BOP system mounted on the well casing. The gas is flared at the surface and control operations are continued until the flow is progressively restricted and stopped. If the kick has occurred and efforts to control and contain the in-flowing formation fluids have failed, an uncontrolled flow or blowout results and re-establishing control may be both technically difficult and dangerous.

The general well control plan must include the procedures to be used to circulate out the kick, and it must also ensure that proper equipment will be available should a kick occur. This includes the BOP system but additionally, casing and drill pipe design and selection are important components of the plan.

In order to carry out the general well control plan, the detailed drilling plan must provide for the integrity of the drilling fluid system throughout the drilling operation regardless of the circumstances encountered. The operator should have on site at critical times experts in geology and mud properties. The operator must also ensure that the drilling and well equipment, particularly the BOP, is functioning properly. Finally, for the general well control plan to be implemented effectively, on-site supervisors and the drilling crew must be properly trained, regularly briefed, and always prepared to act promptly in carrying out prescribed kick control procedures.

5.3 Control Factors at the 13-12 Well

Amoco filed documents providing details of its drilling plan, drilling mud program, rig and well equipment, and qualifications of well-site crew and supervisors. It also provided a detailed chronology of events leading to the blowout, and provided panels of expert witnesses to address the events surrounding the blowout.

After careful scrutiny of the many details, the Panel has concluded that the following areas appear most important with respect to loss of control in drilling the 13-12 well:

(a) integrity of the drilling mud system,

(b) integrity of the drilling and blowout prevention equipment, and

(c) human factors relating to the event.

Figure 5.1 is a sketch showing the layout of the drilling, blowout prevention, and mud circulating system.

5.4 Integrity of the Drilling Mud System

The integrity of the drilling mud system at the 13-12 well during critical periods from 13 to 17 October was primarily a function of the mud density, drilling practices during coring, effects of H_2S on mud properties, and adequacy of active mud supply and the mud supply replacement system.

5.4.1 Density of the Drilling Mud

In developing its drilling plan, Amoco reviewed information concerning formation pressures encountered at a large number of other wells in nearby areas. These indicated that the pressures in the formation of interest at the 13-12 well would ordinarily be around 33 000 to 35 000 kPa. In isolated cases, pressures as low as 22 430 kPa and as high as 46 540 kPa had been reported. Amoco decided to design the drilling mud density to meet a pressure of 33 600 kPa with provision for increasing the density if higher pressure was encountered.

Amoco also indicated that its normal practice was to design mud density to provide a mud column overbalance of some 1500 kPa above the expected formation pressures. During drilling or coring operations, mud pump pressures would add further to this, resulting in an overbalance which should avoid the possibility of excess fluid head and lost circulation but at the same time prevent influx of reservoir fluid.

Calculations by the Panel indicate that, at the predicted Nisku reef depth of 3035 m, the planned mud density of 1150 kg/m^3 would result in an overbalance of some 630 kPa relative to the expected pressure of 33 600 kPa. Since hydrostatic pressure is directly proportional to the vertical height of the mud column, true vertical depth and not measured depth must be used in these calculations.

Additional pressure resulting from the mud pump would be in the order of 600 kPa, resulting in a planned overbalance of some 1230 kPa while circulating the mud. However, the pump pressure is not always present and when hoisting the drill pipe out of the hole, there is a swabbing effect that would further reduce the bottomhole mud column pressure.

Actual mud density was 1165 kg/m^3 when the Nisku was penetrated at 3024 m true vertical depth (3051 m measured depth). This would have resulted in an overbalance of 950 kPa relative to an expected Nisku formation pressure of 33 600 kPa. The mud density was later increased to 1175 kg/m^3 prior to the start of core

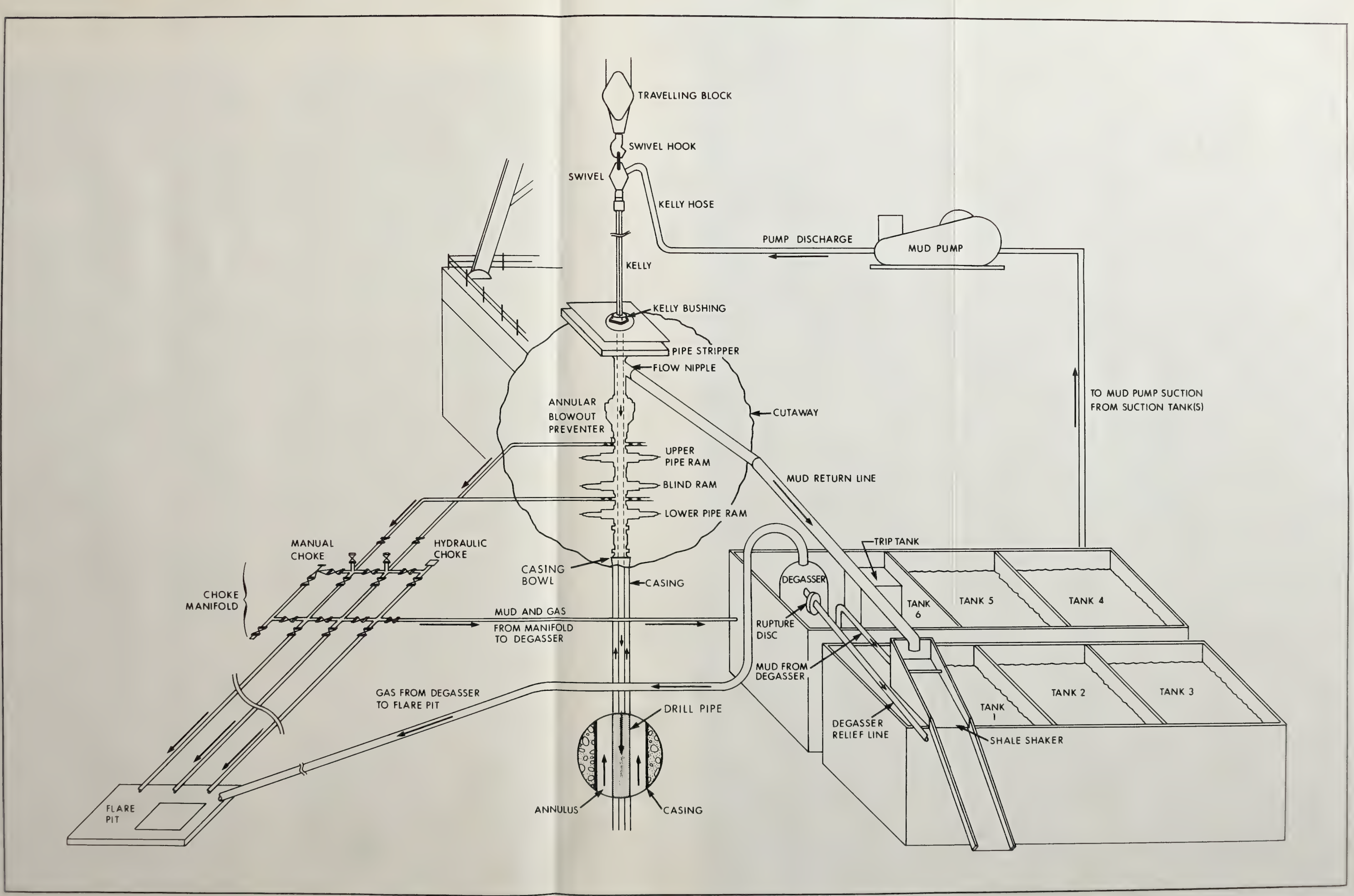


FIGURE 5.1 DRILLING, BLOWOUT PREVENTION, AND MUD CIRCULATION SYSTEM. Not to scale.

No. 3. If the actual mud weight of 1175 kg/m^3 is considered when core No. 3 was broken off, an overbalance of 1246 kPa would result relative to the top of the Nisku formation and 1418 kPa at the bottom of core No. 3.

As indicated earlier in this section, it is necessary to use a mud density which is neither too low, thus allowing an influx from the formation, nor too high, which could result in lost circulation. This means there is a range of mud density within which operations must take place. The closer one is to the upper or lower limit, the more careful drilling procedures must be. If the mud density is within the range but towards the "high limit", care must be taken to avoid lost circulation. For example, the mud volume must be carefully monitored and the crew must be ready to add lost circulation material. If the mud is closer to the "low limit", drilling must proceed slowly, the potential for a kick must be carefully monitored, and plans to quickly weight up the mud must be in place.

The range of appropriate mud densities varies for each situation, and at the 13-12 well, because of the high reservoir pressure with very good permeability, it was likely relatively narrow. The planned pressure overbalance of 630 kPa, plus or minus the effects of operations such as pumping or pulling out of the hole, was less than the 1500 kPa normally used by Amoco. As noted previously, the effect of encountering the Nisku formation somewhat higher than predicted, at 3024 m rather than 3035 m, was to lower the "planned" overbalance even further. On the other hand, the actual mud weight of 1165 kg/m^3 for cores No. 1 and 2 and 1175 kg/m^3 for core No. 3 was greater than the planned weight of 1150 kg/m^3. Notwithstanding, there is an indication that the planned mud density was on the low side of the range, even though it was increased during drilling. The on-site supervisor should have been aware of this and thus should have planned to use particularly cautious procedures in coring into the Nisku formation.

The above assessment relates to theoretical calculations and planning for the proposed mud density. Actual experiences during operations at the well are of utmost importance and must also be considered when drawing conclusions respecting the adequacy of the mud density. With respect to these operations, no kicks were experienced when drilling into the reef on 13 October, nor during the cutting of cores No. 1 and 2. This suggests the mud density was above the lower limit of the "safe" range. Conversely, records indicate that considerable seepage losses, totalling over 18 m^3, occurred between drilling out of the intermediate casing at 13:00 on 13 October and recovering core No. 2 at 16:00 on 16 October. These losses could have been interpreted by on-site personnel as warnings of lost circulation and that the mud density was approaching its upper limit.

The apparent conflict between the Panel's calculation of required mud density to maintain well control and the reported seepage losses lead it to examine in more detail the validity of these losses. The Panel notes that the reported seepage losses occurred during four separate tripping-out operations, each over a relatively short 4.0- to 4.5-hour time period. The swabbing effect would tend to reduce the hydrostatic pressure, and therefore seepage at these times would be expected to be at a minimum. During other activities, such as tripping in and circulating, seepage would logically have continued at the same or increased rate. Extrapolation of the reported seepage losses to a 24-hour period implies daily losses of 20 to 35 m^3. Losses of this magnitude would be extremely serious and would require suspension of drilling operations and prompt corrective action.

After careful consideration, the Panel concludes that losses in the order of 20 to 35 m^3/day could not have occurred, as they were not reported in any of the evidence. Additionally, the records do not show that drilling operations were suspended or that the addition of drilling mud additives was required to correct a major lost circulation problem. Also, the records do not indicate that large volumes of mud were mixed to replace supplies that were reputedly lost by seepage. The Panel is satisfied that the reported seepage losses of 18 m^3 did not, in reality, occur at least to the extent reported. Instead, the "losses" were likely the result of some undetermined procedural or equipment calibration error.

In summary, the Panel concludes that the planned mud density for the 13-12 well was on the low side and therefore extra care should have been specified during the critical period of drilling into the Nisku zone. Although substantial seepage losses were reported and these might have been interpreted by on-site personnel as an indication that the mud was on the heavy side, an analysis of the situation indicates that the reported losses were likely due to errors. This is an indication that the drilling practices being used were less than satisfactory.

5.4.2 Drilling Practices During Coring Operations

Amoco testified that it had exhaustively reviewed the events preceding the blowout and had great difficulty in developing an explanation as to why the gas kick had started during the core No. 3 operations. Eventually, it concluded that the most plausible reason was that of a swabbing action caused when hoisting the drill string and shutting down the pumps to insert a 4-m pup joint immediately prior to the start of coring. It reasoned that this triggered a momentary underbalance during which gas could have flowed into the wellbore. Amoco indicated this was followed by several additional influxes.

The Panel has also made a careful analysis of all evidence relating to events prior to the blowout. Details of its analysis are presented in Tables 5.1, 5.2, 5.3, and 5.4, and Figures 5.2, 5.3, and 5.4.

Table 5.1 is a summary of the time required for the various procedures during the coring operations.

The most noteworthy time periods are those taken to circulate to bottom and clear trip air (column 3) and for circulation after coring (column 5). These were progressively reduced as operations proceeded from core No. 1 through to core No. 3. These reduced times suggest that drilling practices were becoming lax, and as

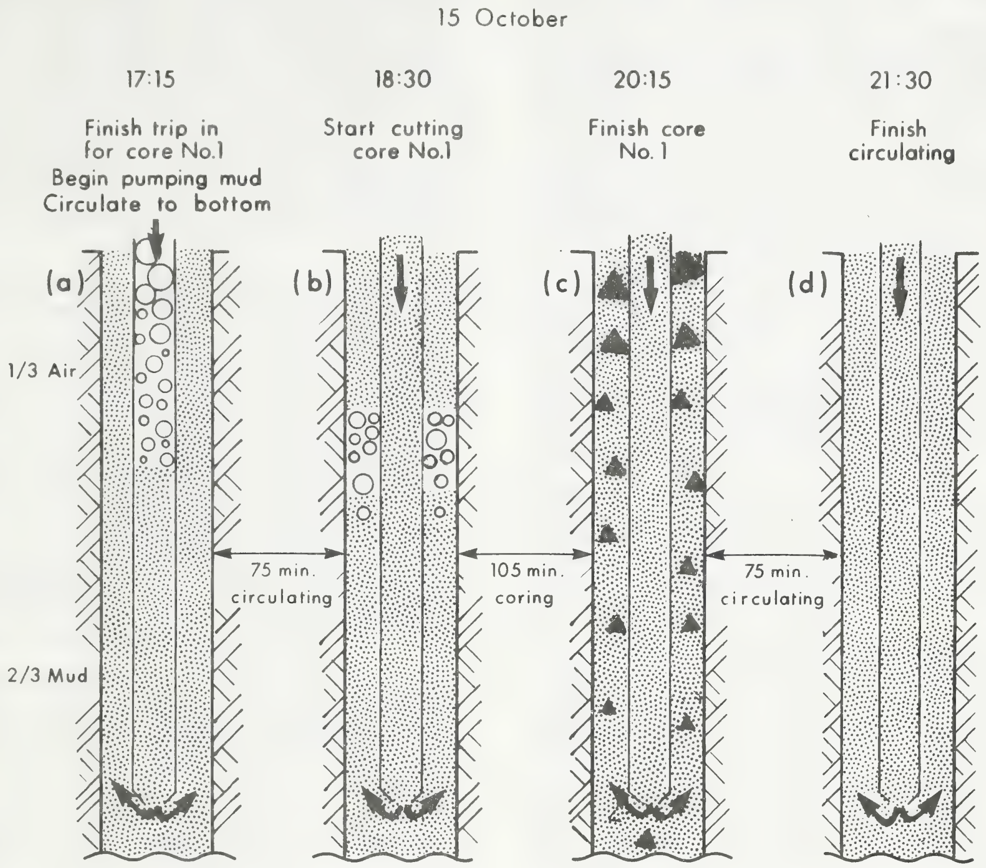
TABLE 5.1 SUMMARY OF TIME REQUIRED (MINUTES) DURING CORING OPERATIONS AT THE 13-12 WELL

1 Core No.	2 Trip In	3 Circulate to Bottom & Clear Trip Air	4 Coring	5 Circulation After Coring	6 Flow Check	7 Trip Out
1	195	75	105	75	15	255
2	240	60	75	30(a)	15	255
3	255(b)	20	55			

(a) 45 minutes, less 15 minutes for flow check.
(b) 330 minutes, less 75 minutes for servicing and crew change.

TABLE 5.2 DETAILED DRILLING PRACTICES WHILE OBTAINING CORE NO. 1 AT 13-12 WELL

Time/Date	Operation	Corresponding Pictorial	Remarks
14:00 15 Oct	Start trip in to cut core #1		- No indication of problems
17:15 15 Oct	Finish trip in for core #1	5.2(a)	- Some 2/3 of pipe filled through hole in float valve, upper 1/3 full of air
18:30 15 Oct	Start cutting core #1	5.2(b)	- After 75 minutes to fill hole and circulate to bottom, trip air displaced about 3/4 up the annulus
20:15 15 Oct	Finish core #1	5.2(c)	- 105 minutes of circulating while coring clears trip air, small amounts of core gas throughout annulus
21:30 15 Oct	Finish circulating	5.2(d)	- Circulating 75 minutes, which is bottoms-up time, clears annulus of core gas, flow check (15 minutes) shows no flow
03:00 16 Oct	Finish trip out & recovery of core #1		- No apparent problems



Note:

20 minutes required to compress trip air and circulate out of drill pipe.

75 minutes required to circulate from bottom of hole to surface.

Legend

▨ Drilling mud

▲▲ Gas released from coring operations

Oo Air from tripping empty drill pipe into hole

FIGURE 5.2 LIKELY WELLBORE SITUATION. Core No.1

coring operations into the formation proceeded without apparent problems, less attention was given to the practices being followed.

Tables 5.2, 5.3, and 5.4, with the assistance of Figures 5.2, 5.3, and 5.4, analyse the coring procedures in detail. The first two columns of the tables show the various times and the particular operations taking place at those times for each of the three cores. The likely state of the wellbore at these particular times is illustrated in the series of pictorials identified in the third column. The remaining column in the tables briefly describes the logic and reasons why the Panel concludes the wellbore situations were as shown in the figures.

While tripping in (Figures 5.2(a), 5.3(a), and 5.4(a)), drilling mud would have entered the drill pipe through the 3.175-millimetre (mm) (1/8-inch) hole drilled in the flapper valve of the drill-pipe bottom-hole assembly. Based on the time required to trip in, it is estimated the drill pipe would fill to two-thirds of its internal volume. The amount of fill actually obtained could have been considerably less if the hole had been plugged, for example, by a piece of rock cutting from the coring operation. Under these circumstances, the amount of air trapped in the drill pipe would have been much larger. However, the time required to circulate the air down the drill pipe and up the annulus would have been approximately the same regardless of the amount of air.

Table 5.2 and Figure 5.2 relate to the first core. They suggest that the practices up to this stage resulted in no apparent problems. The times to circulate to bottom and for circulating after coring were both 75 minutes which is “bottoms-up time”. The annulus would have been cleared of core gas prior to tripping out. The Panel believes it significant that the flow check taken prior to tripping out of the hole with core No. 1 was negative.

Table 5.3 and Figure 5.3 describe what occurred during the cutting and recovery of core No. 2. Procedures appeared to have become somewhat relaxed as compared to core No. 1. For example, the circulate to bottom cycle was discontinued much sooner than with core No. 1 (60 minutes rather than 75 minutes), and the circulation following the coring was for only 30 minutes and was not sufficient to clear the annulus of core gas. While there were no apparent serious problems, at 16:00 on 16 October, prior to commencing operations for core No. 3, the Panel expects that core gas remained in the annulus and could have set the stage for subsequent problems.

Table 5.4 and Figure 5.4 relate to core No. 3. They show that the annulus still contained core gas from core No. 2 and the time taken to circulate prior to coring was not sufficient to clear the annulus of that gas. The consequence would be to reduce the hydrostatic pressure, and coupled with the presence of trip air and the swabbing effect of lifting the drill pipe and core assembly off bottom to install a pup joint, likely resulted in the first influx of gas into the wellbore as shown in Figure 5.4(c).

The Panel believes that there was likely a second influx when core No. 3 was broken off and the pipe was picked up off bottom as shown in Figure 5.4(d). At this stage, air and gas in the annulus would have achieved maximum expansion which may have reduced the hydrostatic pressure of the mud column enough to allow a continuous formation gas influx during the period 22:50 to 23:30 on 16 October, when a flow check was being conducted and the additional pressure from the mud pump was not present. The probability of influxes No. 2 and 3 occurring is supported by a review of the events that followed, culminating at 02:30 on 17 October with a large flow of gas at surface and the first degasser failure. The durations and rates of circulation from 23:00 on 16 October to 02:30 on 17 October was approximately that required to result in an influx at 23:00 arriving at surface at 02:30.

The Panel's assessment respecting the likely timing at which gas influxes into the wellbore may have occurred is identical to Amoco's, except that Amoco made no mention of the possibility of an influx taking place while the flow check was being conducted.

The preceding review indicates that the problems at the well, which eventually resulted in the blowout, started during coring operations and resulted from inadequate hydrostatic pressure to keep gas from entering the wellbore. A heavier mud might have reduced the amount of influx that occurred, particularly when the coring assembly was lifted off bottom. The Panel concludes that the more serious aspects of the problem resulted from inadequate care taken during coring operations. This may have resulted because on-site supervisory personnel did not fully appreciate the potential of the formation into which they were drilling, and the density of the mud being used was such that it would provide only a modest overbalanced condition, and then only when the mud column in the wellbore was adequately maintained.

5.4.3 Effects of H_2S on Drilling Mud Properties

Amoco required that the mud pH be kept relatively high, 10.5 to 11.0, to reduce the possibility of hydrogen ion attack on the drill pipe in the event of H_2S exposure. As well, it required the use of iron oxide scavenger to neutralize any H_2S that might be encountered.

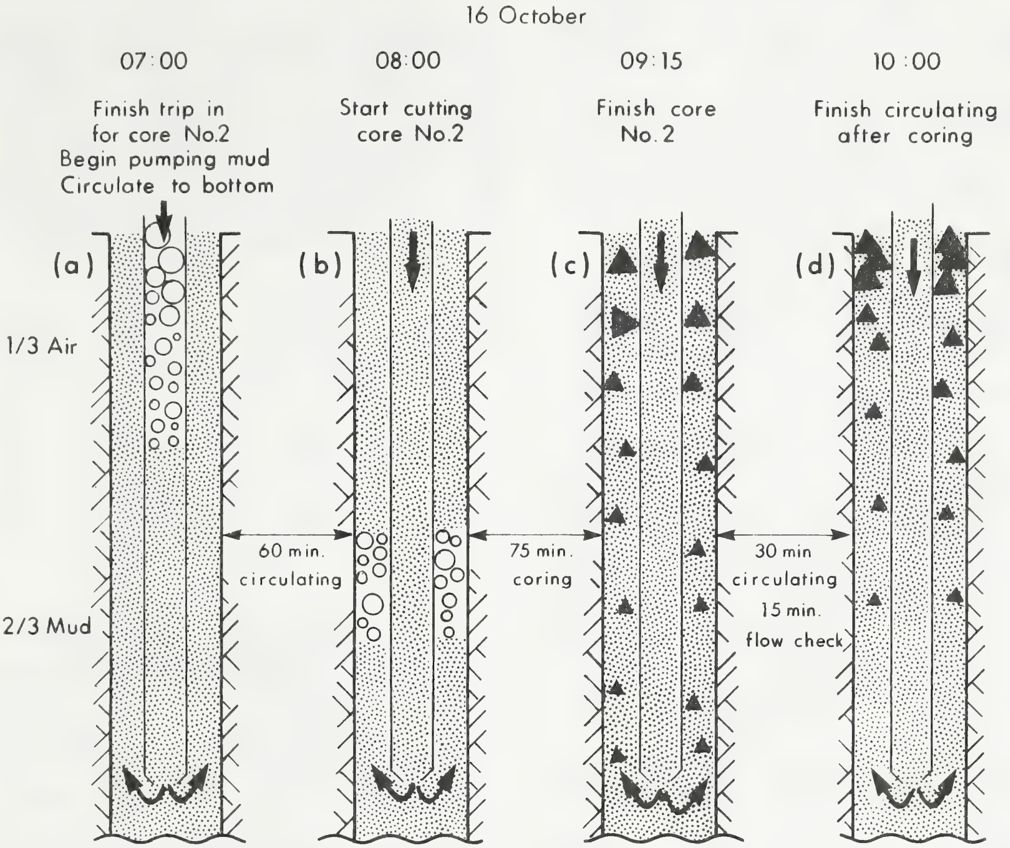
The Panel notes that there is some controversy in industry as to the effectiveness of iron oxide as an H_2S scavenger. The literature reviewed by the Panel indicates that iron oxide has a relatively low reaction rate at high pH. However, the Panel notes the evidence that for the 13-12 well, the H_2S contaminated mud looked black, sticky, and viscous, which tends to confirm that the iron oxide was reacting with the H_2S to form iron pyrite.

The Panel also questions whether a heavily H_2S contaminated mud could be readily reconditioned or be suitable for recirculation as it might not function as an effective drilling fluid.

The Panel concludes that the evidence with respect to the effect of H_2S on drilling mud is not clear. Similarly, the role this may have played in the cause of the blowout is not certain. The Panel notes that the BPRC will be reviewing the use of scavengers, as well as the effect on various mud properties of H_2S contamination.

TABLE 5.3 DETAILED DRILLING PRACTICES WHILE OBTAINING CORE NO. 2 AT 13-12 WELL

Time/Date	Operation	Corresponding Pictorial	Remarks
03:00 16 Oct	Start trip in to cut core #2		
07:00 16 Oct	Finish trip in for core #2	5.3(a)	- Some 2/3 of pipe filled through hole in float valve, upper 1/3 full of air
08:00 16 Oct	Start cutting core #2	5.3(b)	- After 60 minutes to fill hole and wash to bottom, trip air displaced about 1/2 way up the annulus, compared to 75 minutes and about 3/4 for core #1
09:15 16 Oct	Finish core #2	5.3(c)	- 75 minutes of circulating while coring clears trip air, small amounts of core gas throughout annulus
10:00 16 Oct	Finish circulating and flow check	5.3(d)	- Circulating 30 minutes is well short of bottoms-up time (75 minutes) so upper 3/5 of annulus contains core gas which has expanded due to reduced pressure, flow check (15 minutes) shows no flow
16:00 16 Oct	Finish trip out & recovery of core #2		- No apparent problems but some core gas remains in annulus even though gas was rising when mud was not being circulated



Note:

20 minutes required to compress trip air and circulate out of drill pipe.

75 minutes required to circulate from bottom of hole to surface.

Legend:

▨ Drilling mud

▲▲ Gas released from coring operations

○○ Air from tripping empty drill pipe into hole

FIGURE 5.3 LIKELY WELLBORE SITUATION. Core No. 2

5.4.4 Adequacy of Mud Supply and the Replacement System

Amoco indicated that one of its reasons for selecting the Nabors 14E rig for the 13-12 well was that it had modern drilling mud facilities and relatively large capacity mud tankage. Amoco's schematic of the drilling mud system is shown in Figure 5.5. There were 6 main tanks of which tanks 1 through 5 constituted the active system and tank 6 was set aside for holding prehydrated bentonite that could be committed to mud make-up supply as and when required. The capacities of the tanks were:

Main Tanks	Capacity (m^3)	Small Inset Tanks	Capacity (m^3)
1	25.7		
2	28.1		
3	21.5	Mixing	1.2
4	34.0 (suction tank)		
5	31.3 (suction tank)	Pill	5.3
6	23.5 (premix)	Trip tank	6.8
	164.1		13.3

Counting all tanks, the total capacity was 177.4 m^3. After subtracting the premix, mixing, and pill tanks, the net active system tankage at full capacity was 147.4 m^3. However, the bottom approximately 0.45 m of the tanks were effectively dead storage and could not be accessed by the pumps, resulting in some 23 m^3 of unusable storage capacity in the combined active tankage.

In assessing the role which the availability of mud played in the cause of the blowout, the Panel has attempted to reconstruct the mud supply situation commencing with drilling out of the intermediate casing. Unfortunately, the record is not completely clear. The estimated mud supply as pieced together from the evidence is presented in Figure 5.6.

Amoco's mud company service reports fix the volume in the mud tanks as 80 m^3 on 13 October, increasing to 100 m^3 on 16 October. This agrees with evidence at the inquiry that 100 m^3 of mud was available at the time core No. 3 was cut during the late hours of 16 October. Additionally, the evidence indicated that mud was being lost by seepage between 13 and 16 October, but as discussed in section 5.4.1, the Panel doubts that these losses indeed occurred, at least to the extent reported.

Figure 5.6 shows that the mud in tanks 1 to 5, when the first problems were noticed and core No. 3 was broken off, was 100 m^3, of which some 23 m^3 could not be readily pumped. Additionally, there would have been some 109 m^3 of mud in the wellbore and about 20 m^3 of readily accessible prehydrated mud in tank 6. A high-speed mixer and mud ingredients were also available. The situation in the wellbore was very likely that shown in Figure 5.4(d) where the second significant gas influx had just taken place.

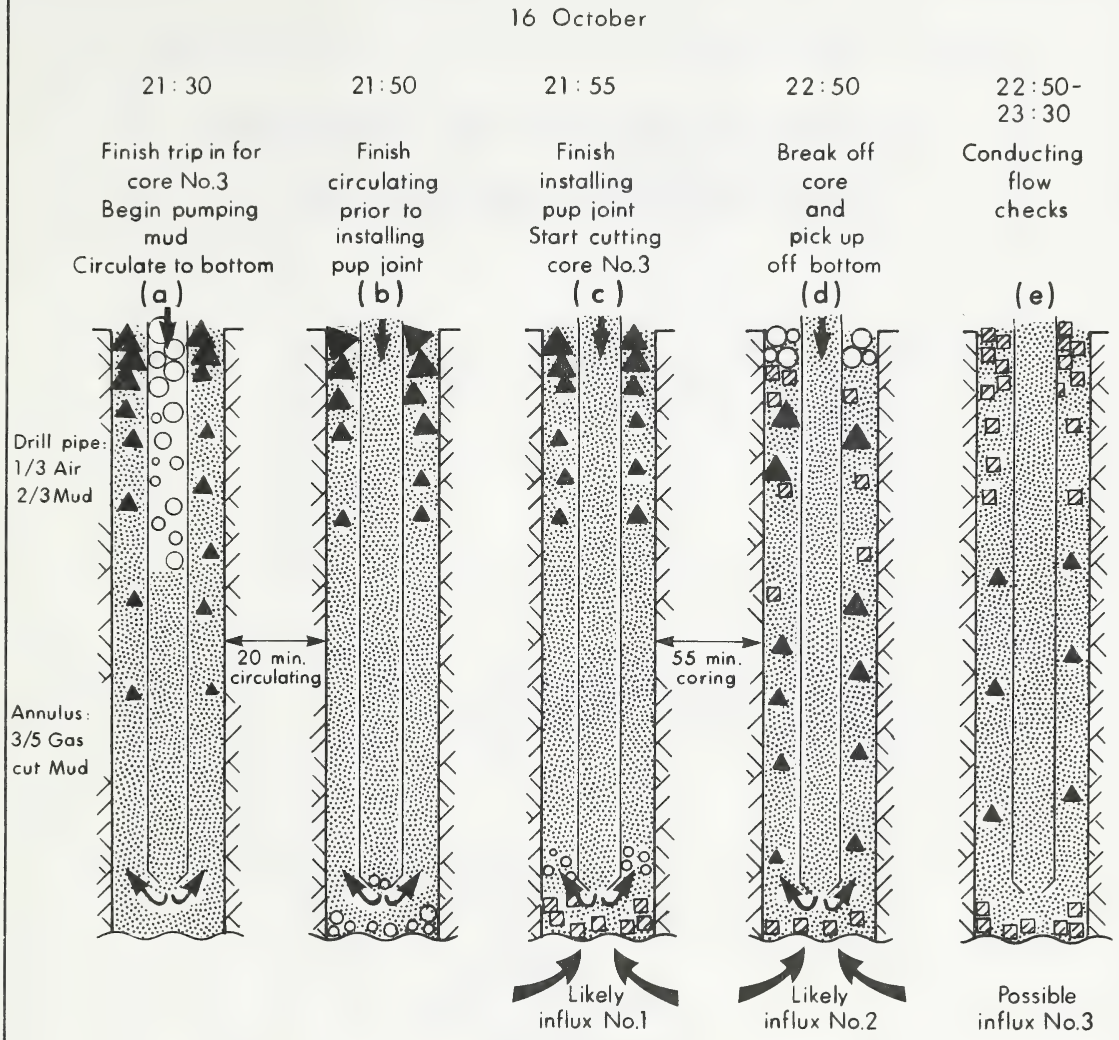
After breaking off core No. 3, flow checks were conducted and the well was circulated. There is no indication of any new mud being mixed or losses in mud volume until the degasser failed for the first time at about 02:30 on 17 October. It was estimated, at that time, that some 10 m^3 of mud had been blown onto the ground and the tanks had gained some 10 m^3 from the wellbore. The tank gain is shown in Figure 5.6. The 20-m^3 loss from the wellbore had presumably been replaced by gas, significantly reducing the hydrostatic pressure.

Amoco estimated that when the degasser failed a second time, 30 m^3 of mud was blown onto the ground. Different items of evidence suggest that, at this time, about 05:00 on 17 October, some one-half of the initial mud was available, and that the active tanks were about one-third full. This would mean there were some 50 m^3 of mud left in the tanks. The Panel has not been able to fully reconcile this estimate with the 100-m^3 supply at the time of the first degasser failure. The circulation which had been interrupted by the first degasser failure would have replaced some of the mud voidage in the wellbore, thus reducing the mud in the tanks. The combination of the circulation and the second degasser failure reduced the mud supply to the 50 m^3 shown on Figure 5.6. At about 04:30, a portion of the prehydrated mud had been mixed with about 15 m^3 of the active mud supply, and the mixture was being weighted up with the high-speed mixer. Whether or not this was part of the 50-m^3 supply is not clear from the evidence.

What then took place in terms of mud supply is equally uncertain. Apparently, mud was being mixed, weighted up, or reconditioned while the degasser was being repaired, and again this might have involved the prehydrated mud. After 08:30 when the degasser repairs were finished, mud was being weighted up and reconditioned for 2.5 hours because it was decided that insufficient mud was available to commence circulation. It is also known that after the drill pipe failed at 06:45, pressure was being bled off through the manifold and some mud would have blown out onto the ground. In any case, the record indicates that after circulating an estimated volume of 15 m^3 from 11:00 to 13:00 at the reduced pump speed, the suction tank volume was used up and circulation again had to cease. Whether this referred to all of the mud available, as is assumed in Figure 5.6, or whether it referred only to the mud that had been adequately reconditioned and weighted up is not clear.

TABLE 5.4 DETAILED DRILLING PRACTICES WHILE OBTAINING CORE NO. 3 AT 13-12 WELL

Time/Date	Operation	Corresponding Pictorial	Remarks
16:00 16 Oct	Start trip in to cut core #3		
21:30 16 Oct	Finish trip in for core #3	5.4(a)	- Upper 1/3 of pipe full of air from trip, annulus still contains core gas due to insufficient circulation after core #2
21:50 16 Oct	Finish circulating, prior to installing pup joint	5.4(b)	- Circulated 20 minutes to fill drill pipe and wash to bottom, annulus may still contain core gas and trip air is compressed at bottom of hole
21:55 16 Oct	Finish installing pup joint, start cutting core #3	5.4(c)	- Annulus may contain core gas at top, contains trip air near bottom, and the swabbing effect of lifting pipe to install pup joint reduces the hydrostatic pressure of fluid column, likely resulting in influx of gas at bottom
22:50 16 Oct	Mud splashing from flow nipple, break off core & pick up off bottom	5.4(d)	- 55 minutes circulating while coring moves trip air and gas influx #1 to top of annulus. The splashing, bubbling, and high gas detector readings observed confirms that the gas influx had reached surface after only 55 minutes of circulating. The circulated bottoms-up time is 75 minutes. This, more rapid than expected movement, is probably due to the buoyancy of the gas influx accelerating the displacement mechanism. While moving up, air & gas expand thus reducing hydrostatic head. Swabbing action coupled with reduced hydrostatic pressure likely results in further influx.
22:50- 23:30 16 Oct	Conducting flow checks	5.4(e)	- Possible additional gas influx takes place when coring stopped and pump pressure eliminated from hydrostatic, may have continued for next 40 minutes while conducting flow checks.


16 October
21:30
Finish trip in for core No.3 Begin pumping mud Circulate to bottom
(a)
21:50
Finish circulating prior to installing pup joint
(b)
21:55
Finish installing pup joint Start cutting core No.3
(c)
22:50
Break off core and pick up off bottom
(d)
22:50-23:30
Conducting flow checks
(e)
Drill pipe: 1/3 Air 2/3 Mud
Annulus: 3/5 Gas cut Mud
20 min. circulating
55 min. coring
Likely influx No.1
Likely influx No.2
Possible influx No.3

Note:

20 minutes required to compress trip air and circulate out of drill pipe.

70 minutes required to circulate from bottom of hole to surface.

Legend

░ Drilling mud

▲▲ Gas released from coring operations

○○ Air from tripping empty drill pipe into hole

▨▨ Gas influx from formation

FIGURE 5.4 LIKELY WELLBORE SITUATION. Core No.3

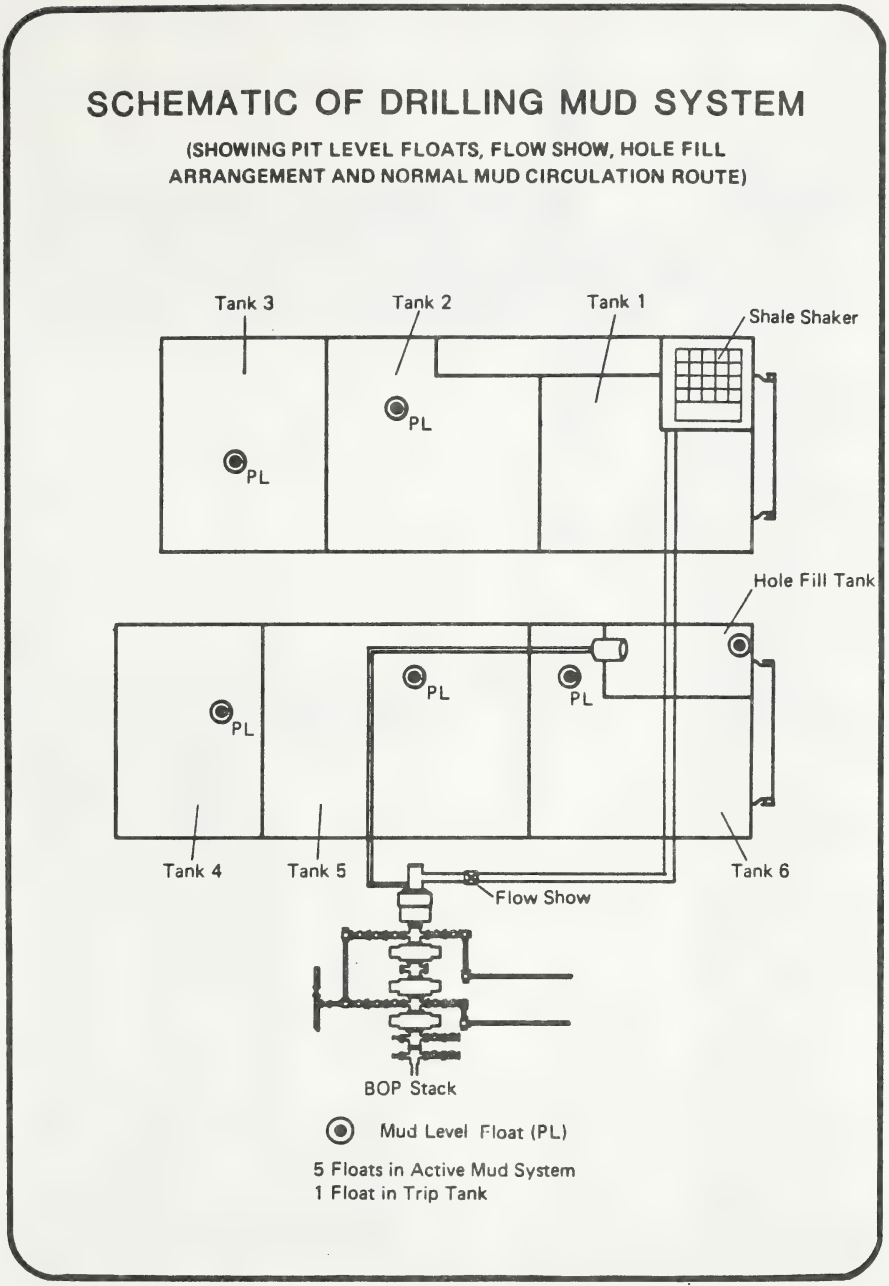

SCHEMATIC OF DRILLING MUD SYSTEM
(SHOWING PIT LEVEL FLOATS, FLOW SHOW, HOLE FILL ARRANGEMENT AND NORMAL MUD CIRCULATION ROUTE)
Tank 3
Tank 2
Tank 1
Shale Shaker
PL
PL
Hole Fill Tank
PL
PL
PL
Tank 4
Tank 5
Tank 6
Flow Show
BOP Stack
Mud Level Float (PL)
5 Floats in Active Mud System
1 Float in Trip Tank

FIGURE 5.5 AMOCO'S SCHEMATIC OF DRILLING MUD SYSTEM.
Reproduced from Exhibit No. 66.1.

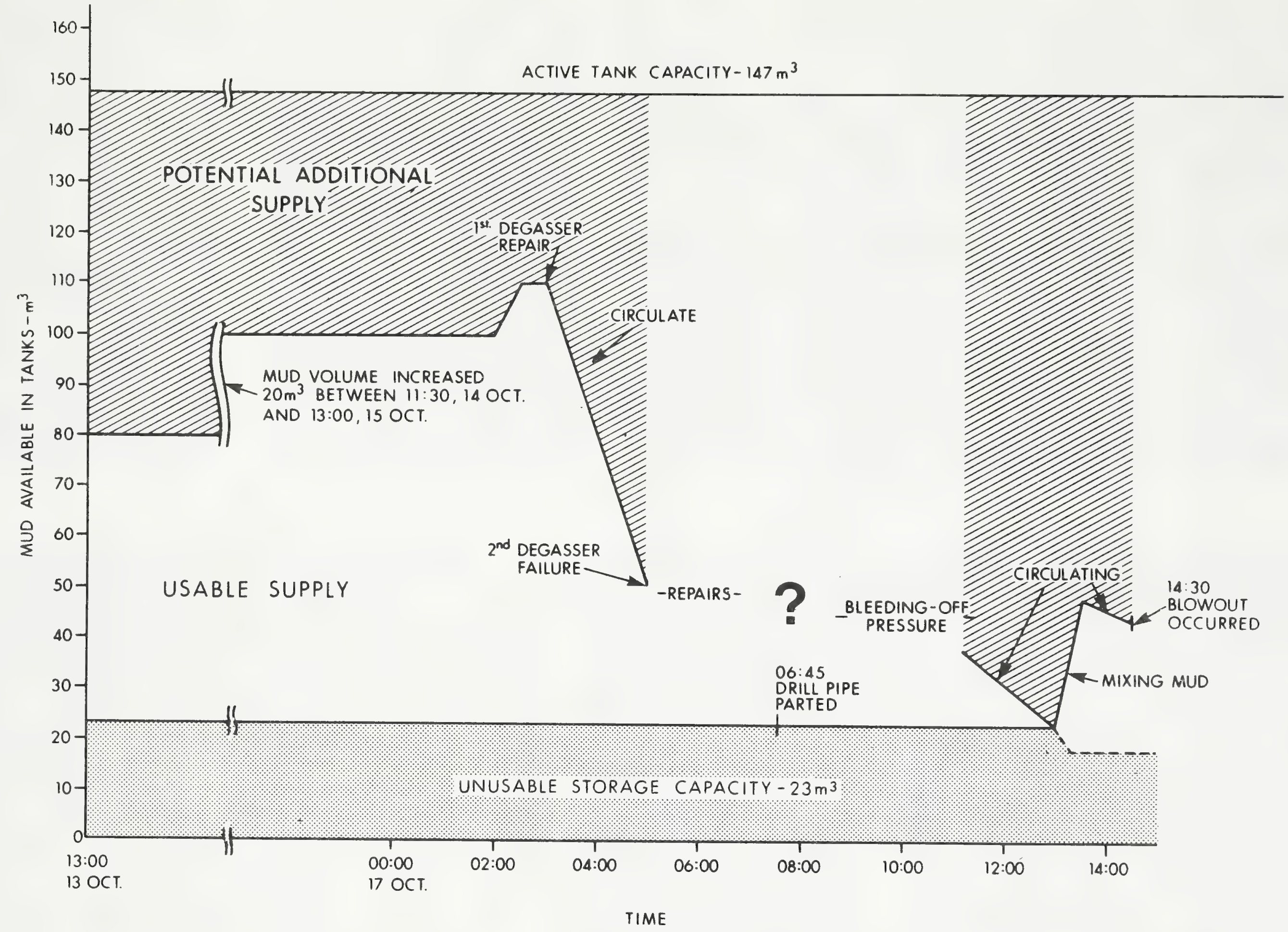


FIGURE 5.6 ESTIMATED MUD SUPPLY AT SURFACE OF THE 13-12 WELL. **Assuming no seepage losses.**

? - Period of uncertainty respecting mud supply. The evidence indicates that some new mud mixing, reconditioning, and weighting up took place in the period 05:00 to 11:00 but volumes and other details are not clear.

An additional 25 m^3 of mud was then obtained by mixing some new mud, and by combining the “unusable storage capacity” (Figure 5.6) into one tank. Circulation was recommenced at about 13:30, but only intermittent returns were obtained, suggesting that the hole contained large volumes of gas. The well blew out of control at 14:30.

The preceding review clearly indicates that insufficient mud was available during the kick-control operations. To illustrate, circulation could not recommence at 08:30 on 17 October when the degasser repairs had been finalized, but had to wait for mud to be weighted up or reconditioned. Amoco also ran out of mud at 13:00 and again had to cease circulation. Also, if there had been sufficient mud available, it may have been possible to continue pumping with the mud being circulated to the flare pit when the degasser failed the first time. Although such action would not normally be expected, it would have allowed kick-control procedures to continue uninterrupted and may have improved the situation.

It is not certain as to whether the kick would have been controlled if additional mud had been available, but the Panel believes there is a good chance that it may have been. Inadequacies in mud supply and the mud replacement system were thus a significant factor in terms of the cause of the blowout.

The remaining question relates to the reasons for these inadequacies. It is clear that no more than approximately 80 m^3 of accessible mud was in the tanks, other than the prehydrated mud, after the intermediate casing was drilled out. That supply was less than the volume of mud in the hole (109 m^3) and represented only about two-thirds of the capacity of the mud tanks. This may be in accordance with common industry practice, but subsequent events demonstrated it was inadequate for drilling into a potentially sour zone. This suggests that a more cautious approach of ensuring that a greater supply of mud is available would be appropriate when drilling in critical sour zones.

Amoco had chosen to use a high-speed mixer along with the 20 m^3 of prehydrated mud, rather than a much larger standby volume of ready mixed mud. The reasons given for this was that greater flexibility was provided because the mud in the active system could be conditioned or weighted up in a very short time with the high-speed mixer to whatever conditions were required, whereas the standby mud would have been designed ahead of time and may well have been at the wrong density, thus requiring further processing. The evidence did not suggest that the availability of mud was affected by the mixer itself. However, given insufficient supplies of mixed mud on at least two occasions, the Panel must conclude, with the benefit of hindsight, that a premixed supply of mud would have assisted in efforts to control the kick. From this experience, the Panel concludes that there must be an appropriate back-up mud system for critical sour wells. It believes the BPRC should consider this matter and make recommendations.

It also appears that manpower was not available at the 13-12 well to mix mud when repairs were being made to the degasser and other equipment. Since additional crew members were available at the nearby camp and were not called out to assist, this suggests that the on-site supervisor did not treat the situation as seriously as he might have. This may have resulted from inadequate planning by way of emphasizing to the on-site personnel that sour gas was a possibility and that the avoidance of a blowout was particularly critical.

Consideration of this aspect of the event also raises the question of whether a sufficient number of masks and spare air cylinders would have been available had they been needed and additional crew members been called out. The Panel believes that, for critical sour wells, consideration should be given to changing the regulations to ensure that masks and air cylinders are also available for extra people that may be called onto a well site to deal with an emergency, and that such people are trained in the use of the masks. The matter of air masks and their usage is dealt with in greater detail in section 6.

5.5 Integrity of the Drilling and Blowout Prevention Equipment

5.5.1 Failure of the Degasser

Figure 5.7 is a cross-section of the type of degasser used at the 13-12 well.

During the initial attempts to circulate out the kick, from 23:30 on 16 October to 02:30 on 17 October, weighted mud was being gradually pumped into the well as an essential part of the kick-control procedure. When the degasser failed at 02:30, spilling an estimated 10 m^3 of mud out onto the ground, kick-control circulation was stopped for 30 minutes to permit repairs. The well was shut in during these repairs, therefore, any influx into the well would cease after a short period of build-up to stabilized pressure conditions within the wellbore. During an earlier shut-in period, from 01:00 to 01:45, the pressure build-up occurred in about 30 minutes. The Panel, therefore, concludes that the first degasser failure and the short 30-minute cessation of kick-control procedures probably allowed some influx but was not likely a significant contributor to the cause of the blowout.

Following repairs to the degasser, circulation was resumed for only 2 hours from 03:00 to 05:00, initially with no mud returns, when the degasser failed a second time as a slug of H_2S-exposed, gasified mud drove the float into the mud-outlet position. In this instance, repairs required some 3.5 hours, and with additional time for other repairs and mud mixing, circulation ceased for 6 hours.

As with the first degasser failure, the second should not in itself have been a major cause for concern, provided the well was shut in and pressure allowed to build up to prevent further influxes and the drill pipe was adequately protected. Initially, the well was shut in. However, after 1.75 hours, the drill pipe failed and the well was bled off to prevent the pressure from building up and forcing the drill pipe out of the hole. Undoubtedly, this led to very large influxes, and more seriously, loss of additional mud from the wellbore.

The Panel concludes that the failures of the degasser should not by themselves be regarded a primary cause of the blowout. However, the failures interrupted kick-control procedures and resulted in the drill pipe being exposed to H_2S without the protection provided by the circulating drilling mud. Eventually, the drill pipe failed and this was critical in terms of the cause of the blowout. In that sense, the degasser failures contributed in a major way to the blowout. This analysis confirms the need to have all components of a drilling system operating effectively.

Evidence at the inquiry indicated that the type of degasser installed on the Nabors 14E rig was not unusual for a closed mud system, and was in use on several other rigs in the province. Prior to the 13-12 incident, that type of degasser had apparently operated effectively but, as the Nabors crew testified, its efficiency had not been tested until an actual gas kick developed. While the Panel is satisfied that Amoco applied reasonable judgement in approving the Nabors degasser (Figure 5.7), it notes that Amoco, as a result of the 13-12 experience, recommended changes to the degassers.

The Panel agrees that degasser design should be evaluated, particularly for use on sour wells, and the design should be proven before use in the field. The Panel has specifically included a review of degasser design in the Terms of Reference for the BPRC. Until the committee has reported, and a more permanent policy is established, the Panel believes that drilling rigs on critical sour wells should either be equipped with a spare degasser in parallel, or some other equally effective system and related procedures, to be used in the event of a degasser failure.

5.5.2 Failure of the Drill Pipe

At 06:45 on 17 October, while the degasser was being repaired for the second time, the drill pipe parted, most likely due to hydrogen embrittlement caused by exposure to H_2S.

In preparing to drill the well, Amoco had the option of using either Grade E or Grade G drill pipe. The latter is more prone to failure due to hydrogen embrittlement, but provides greater strength if it can be protected from the effects of any H_2S that may be encountered. The increased strength was important in the case of the 13-12 well because of the projected depth, and also because of it being a directionally drilled hole. Amoco chose to use a combination of the E and G grade drill pipe, and to protect it by maintaining the pH of the mud at a relatively high level while adding iron oxide to the drilling mud to neutralize any H_2S contamination. The Panel accepts the logic of the Amoco position and does not see this as a deficiency in planning on the part of Amoco, even though hindsight reveals that a larger diameter, thicker wall Grade E drill pipe would have been a better choice.

Drill pipe design and the use of H_2S scavengers are both matters that have been referred to the BPRC. As well, the BPRC should look at other measures to protect drill pipe, including the internal coating of the pipe with plastic, or externally coating it with film forming inhibitors.

A related matter at the 13-12 well is that once the drill pipe parted, the upper portion was eventually forced out of the hole by the pressure. Amoco indicated that it had considered tying down the pipe with chains but had discarded this option because of the need to go under the rig floor to anchor it and the possibility that in doing so the pipe might be disturbed and begin to hydraulic again. Special snubbing equipment was ordered from Red Deer, but too late for it to arrive in time to be of assistance. The Panel believes the BPRC should look at more effective ways of anchoring the drill pipe in such situations.

5.5.3 Failure of the Casing Pressure Instruments

The diaphragm in one of the two casing pressure sensors had ruptured, allowing drilling mud to enter and plug off the hydraulic line to the pressure gauge in the manifold house. The second pressure sensor was connected by hydraulic line to a pressure gauge located on the rig floor, and the hydraulic line was found to be frozen off. As a result, neither pressure gauge was functioning properly.

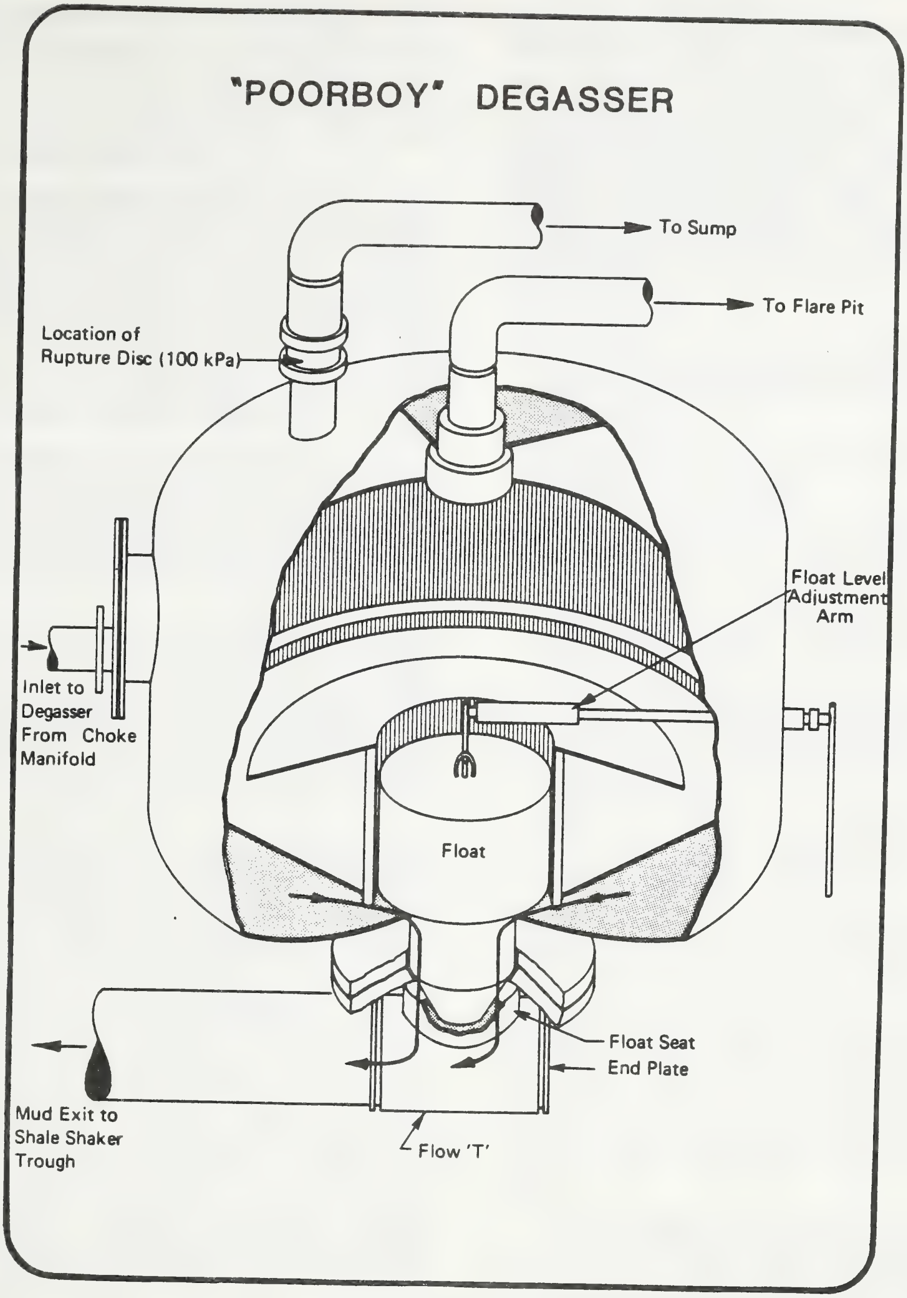

"POORBOY" DEGASSER
To Sump
To Flare Pit
Location of Rupture Disc (100 kPa)
Float Level Adjustment Arm
Inlet to Degasser From Choke Manifold
Float
Float Seat
End Plate
Mud Exit to Shale Shaker Trough
Flow 'T'

FIGURE 5.7 AMOCO'S DIAGRAM OF THE "POORBOY" DEGASSER. Reproduced from Exhibit No. 66.

The combination of the inside of the drill pipe and the annulus of a drilling well can be compared to the two legs of a U-tube. Under stabilized conditions, the sum of the pressures in each leg of the U-tube must be equal, whether the pressures are static or result from one or more partial columns of fluid.

Because the drilling fluid is circulated down the inside of the drill pipe and up the annulus, formation fluids entering the bottom of the well during a kick do not usually enter the drill pipe, but instead are circulated up the annulus. As a result, the sum of hydrostatic pressure of the column of mud in the drill pipe, which usually does not contain entrained formation gas, plus shut-in drill-pipe pressure at surface (SIDPP), is a direct measure of the pressure at formation depth in the well.

Because of the U-tube effect, a comparison of the shut-in casing pressure at surface (SICP) to the SIDPP will provide important information as to the fluid content of the annulus. In a kick situation, it is usual to have the SICP greater than the SIDPP, indicating the presence of gas in the annulus.

When influx No. 1 appeared to reach the surface at 22:50 on 16 October (Figure 5.4(d)), some mud was noticed bubbling and spashing from the flow nipple. Mud circulation was stopped and a flow check was conducted. Additionally, an H_2S odour was noticed on the rig floor. With the annular BOP then shut in, the SIDPP and SICP were reading zero.

At about 23:30, Amoco proceeded to circulate at reduced pump speed through the manifold and degasser with the annular preventer closed. Circulation continued until 00:45 on 17 October when circulation was stopped and the annular preventer was opened. A flow check was conducted and no flow was observed. Conventional circulation, with the annular preventer open, ie, direct to the tanks, was continued until 01:00 when a flow check indicated that the well was flowing. At this point, Amoco shut in the annular preventer and again determined the SICP which was zero and the SIDPP which was 2000 kPa. Even though the evidence suggests that Amoco did not become aware of the possible failure of the casing pressure instruments until approximately 01:45 on 17 October, it, at this point, appeared to assume that a kick had been taken and carried out kick-control calculations and commenced prescribed kick-control procedures.

The Panel believes that as a result of the failure of the casing pressure instruments, Amoco lacked information important to determine conditions in the wellbore when the first influx reached surface and may have failed to realize it had a serious kick on its hands. This likely explains why Amoco did not initiate kick response procedures at 23:30 but instead continued with various observations and other actions for almost 2 hours.

Amoco provided, with its documentary evidence, a copy of the kick circulation procedure posted on the wall of the doghouse at the Nabors 14E rig. According to the evidence, the drilling crew was required to follow the methods set out in that procedure. The highlights of the prescribed well control procedures are set out below, but the additional information in parentheses have been added by the Panel.

Kick Circulation:

1 Determine stabilized SIDPP and SICP.
(Both the drill pipe and annulus most be closed during this step.)

2 Start mud pump at reduced circulating rate.
(The drill pipe is opened.)

3 Adjust manifold choke to allow casing pressure to build up to SICP plus a suggested margin of 1400 kPa maximum.
(The annulus remains shut-in until the desired casing pressure is reached, at which point attention is directed to the drill-pipe pressure.)

4 Read drill-pipe pressure and maintain it constant by manifold choke adjustment, at a pressure equal to SIDPP plus reduced-speed pump pressure plus a nominal overbalance.

5 While circulating the kick, maintain constant, reduced, pump speed and hold drill pipe pressure constant by manifold choke adjustment.

After the kick has been circulated out, the well is killed in a second phase by increasing mud density and circulating the weighted mud in a prescribed manner.

The actions taken at the 13-12 well did not, during the first couple of hours, conform to Amoco's procedural requirements probably because it did not recognize that a kick had been taken. Two significant differences between the actions taken and those that probably would have been taken had the kick been recognized were as follows:

1 Circulation pressure from 23:30 on 16 October to 00:45 on 17 October would have been higher than the 2000 kPa used. It should have included an appropriate overpressure allowance of perhaps 1800 kPa as was used starting at 01:45 on 17 October. In order to introduce any overpressure at constant reduced pump speed, Amoco likely would have partially closed off the manifold choke. This would have resulted in an overpressure in both the casing and drill pipe, and would have ensured that no further influx took place at formation depth.

2 Circulation through the BOP manifold and degasser with the annular preventer closed would not have been interrupted at 00:45 on 17 October. Amoco's objective at this point should instead have been to continue circulating until it was certain any influx had been displaced out of the wellbore. This would have required a minimum of 150 minutes at reduced pump speed and would have ensured complete displacement of any gas that may have been in the annulus.

Throughout the situation previously described, a determination of casing pressure was desirable for the following specific reasons:

1 The difference in SIDPP and SICP is a direct measure of the difference in the hydrostatic pressure of the fluid in the drill pipe and casing, and therefore by difference, an indication of the magnitude of the influx that has taken place. An appropriate course of action is dependent on knowing both pressures.

2 In initiating standard kick-response procedures, the well remains shut-in as mud is pumped into the drill pipe until the casing pressure builds up to the pre-established SICP plus an appropriate margin to ensure pressure overbalance at formation depth to prevent further influx of formation fluids. Thereafter, the drill-pipe pressure primarily, but also the casing pressure, is monitored as kick-response procedures are continued.

It is possible that the course of action that Amoco followed in the absence of the casing pressure readings may have succeeded if other events had not intervened. The readings were certainly important, however, and the absence of them probably contributed to some of the uncertainties and delayed actions which appeared to exist during the initial responses to the first kick.

The preceding analysis illustrates the importance of the casing pressure instruments and the effect their failure may have had on the blowout. It also illustrates the potential consequence of any lack of rig equipment maintenance, which was the case with respect to the casing pressure sensor and gauges at the 13-12 well.

The Panel believes that improved training should stress to drilling personnel the importance of casing pressure, and the need for proper maintenance of instruments. Training and casing pressure sensors are both matters that have been referred to the BPRC.

5.5.4 The BOPs

Various components of the BOP stack were used extensively starting on 16 October when the kick was first experienced. Until the blowout occurred at approximately 14:30 on 17 October, the units all performed as required. Amoco's diagram of the BOP assembly is shown in Figure 5.8.

After the blowout occurred, there were concerns respecting exposure of the BOP stack and its electrical controls to the corrosive effects of H_2S. Similarly, the drill pipe that shot out of the hole on 1 November, and the fire that resulted, both damaged the BOPs. The post-event materials studies showed that the BOPs lived up to H_2S resistant ratings where those were specified.

Some of the participants at the inquiry questioned why shear rams were not installed in the BOP stack. While shear rams have been used in special circumstances, such as offshore drilling, they have not been used extensively in Alberta, and evidence at Phase 2 of the inquiry indicated both advantages and disadvantages to their use.

The Panel has asked the BPRC to look into many aspects of BOP equipment, including the use of shear rams, the need for H_2S resistant external BOP components, and the need to move the BOP master controls away from the well to reduce the possibility of direct exposure to H_2S.

5.5.5 Failure of the Travelling Block Hook Latch and Kelly Hose

The situation at the 13-12 well moved from a controlled kick to blowout status as the latch and kelly hose both failed in quick succession at 14:30 on 17 October. The block hook and latch assembly had been checked by the manufacturer's representative only a few days previously and was deemed suitable for service. It is interesting that the hook latch also failed at the SHELL ET AL UNIACKE G-72 well, but in that case, the kelly fell against the derrick and no strain was placed on the kelly hose to cause it to fail.

The Panel believes that there is a need to investigate improved designs and/or maintenance procedures for the hook latch. Similarly, there is a need to develop stronger kelly hose, trace the kelly hose with a chain or other material to absorb tensile stresses, or require a safety chain across the V-door of the drilling rigs. The BPRC should investigate these matters.

5.6 The Human Factor

Evidence presented at Phase 2 of the inquiry emphasized that human error was believed to be the most important factor in blowouts. Based on that belief, many witnesses contended that emphasis should be placed on training and careful selection of personnel. Particular emphasis was placed on the need for experience and knowledge in being able to satisfactorily deal with kick situations.

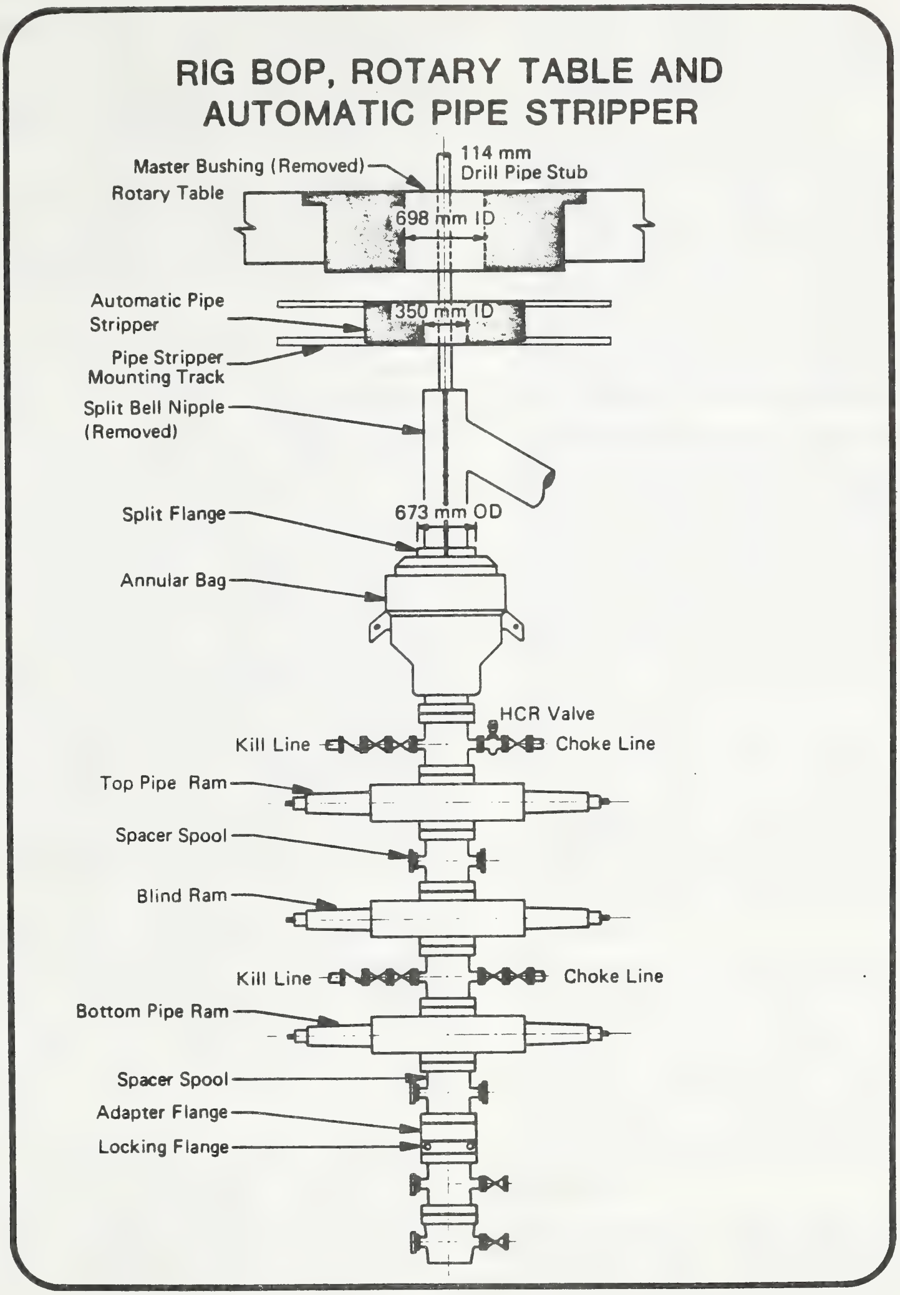


FIGURE 5.8 AMOCO'S DIAGRAM OF THE BOP, ROTARY TABLE AND AUTOMATIC PIPE STRIPPER.
Reproduced from Exhibit No. 66.

For the 13-12 well, the human factor was an important element in the selection of the drilling rig, the adoption of the drilling program, and the execution of that program in actual drilling operations. Decisions made in each of these areas had an influence on the final outcome.

With respect to drilling operations, the evidence shows that a kick occurred on 16 October around 22:50. Kicks do occur in the drilling of wells but are expected to be successfully circulated out of the system. This was not achieved and the well blew out of control.

Evidence presented at the inquiry indicates that the supervisors and drilling crew were well trained and experienced. There were, however, as indicated earlier, apparent errors or omissions in drilling practices and kick-control procedures. In this regard, the Panel believes it significant that the Amoco drilling foreman had been awake and working for more than 24 hours and the Nabors supervisor for 30 hours by the time the well blew out. Amoco gave evidence that it had staff and expertise available in Drayton Valley, Calgary, and indeed other parts of the world to assist personnel on site, yet, the on-site supervisors did not obtain additional help until problems had progressed for some time and were becoming very serious. While their actions in this regard may not have been unusual in the drilling industry, the Panel believes that under emergency conditions there is a need to ensure that the optimum decision is made. That can be achieved by having the people with the best knowledge and experience address the problems in a timely manner before they become critical.

The Panel is also concerned about the overall planning that preceded the actual events. It accepts that the normal or standard planning for contingencies probably took place. However, as events unfolded it turned out to be insufficient. Planning should address the matter of actions which would be taken in the event of various scenarios of unlikely occurrences or worst-case conditions.

The 13-12 well became a serious blowout because of a series of kicks and failure in the application of prescribed kick-control procedures during the night of 16 October and morning of 17 October. As indicated previously, the Panel is of the view that the kicks occurred primarily because Amoco did not employ sufficiently cautious practices during drilling. The kick-control procedures did not commence soon enough, or if they did, they were not totally consistent with prescribed procedures and were interrupted at a time when they should not have been, either because of human error or equipment failure. This raises the questions of whether existing control procedures are adequate for critical sour wells, whether training in these areas is adequate, and whether special expertise is needed on site for certain critical wells. The Panel also recognizes that existing procedures do not provide for the unexpected, such as the failure of equipment.

The Panel believes the BPRC should consider these matters. The BPRC should review the standard control procedures in some detail to ensure that they are sufficiently refined and determine if additions to them might be made to better deal with the unexpected during their implementation. The committee should also focus attention on the frequency and degree of training, the extent of on-site BOP and kick-control drills, and the matter of crew meetings necessary to ensure maximum efficiency when kicks are encountered.

The Panel also believes the committee should look at the level of expertise necessary during particularly crucial phases at critical sour wells. The need for a special expertise, in addition to that provided by the drilling foremen, should be considered, along with the role of the back-up drilling foreman during emergencies, and any other steps that would ensure optimum decisions at important stages. The appropriateness of an increased role for the ERCB in terms of ensuring that kick-control procedures are adequate and rigidly adhered to should also be considered.

5.7 Summary of Panel's Views

On the basis of the foregoing analysis, the Panel concludes that the 13-12 well blew out because a series of sour gas kicks, which occurred while coring in the Nisku formation, were not controlled. It further concludes that no one element in the chain of events was the sole cause of the blowout.

The initial entry of reservoir fluids into the wellbore was probably due to a combination of a mud weight which provided only a modest overbalance and the crew not adequately recognizing the need for extreme caution under these circumstances and not adhering to sound drilling practices. Amoco's initial response to the first kick was inadequate, probably because it failed to realize it had a kick due to the failure of the casing pressure instruments.

If the degasser had operated effectively, the kick may have been circulated out of the system. Even with the failure of the degasser, control may have been maintained if there had been sufficient and properly weighted mud on hand to pump into the well. If the decision had been made to use H_2S resistant pipe for the full drill string, the pipe might not have parted and the well might not have blown out. Additionally, the failure of other equipment, such as the casing pressure instruments, the travelling block hook latch, and the kelly hose, played a role in the cause of the event.

With respect to Amoco, the Panel concludes that its judgement was reasonable with respect to the degasser design, and to a lesser extent, the choice of drill pipe, even though both of these elements failed and were causative factors in terms of the blowout. Such is not the case regarding the drilling practices followed while in the critical zone, the implementation of well-control procedures, plans to ensure the availability of adequate volumes of drilling mud in emergency circumstances, and the maintenance of equipment such as casing pressure instruments.

It is clear from the evidence at both phases of the inquiry that great care is necessary in the planning for and drilling of wells, particularly where sour gas may be involved. It is also evident that the human factor played a major role at Lodgepole, as appears to be the case at most blowouts. Extra effort is needed for critical sour wells to ensure that on-site personnel are well trained and continuously aware of the potential ramifications of a blowout or even a kick, and that special caution is taken to avoid them and to deal with unexpected problems. Special procedures should be developed and utilized to ensure this is done.

The Panel's review of the 13-12 incident indicates that Amoco did not take extra steps to ensure that all operations in the critical zone were in accordance with the highest of standards. Why this was not done is not clear, particularly having in mind that Amoco had experienced a blowout a few years earlier in a nearby well, and consequently knew the potential danger of drilling in the area.

The Panel believes that Amoco should review, at a very senior level, the policies and procedures that apply to the drilling of critical sour wells, to ensure that the lessons of the Lodgepole blowout are fully recognized in the planning for such wells and in the execution of those plans. The Panel believes that the ERCB should do likewise and indeed knows that the ERCB has under way a detailed review of drilling practices for sour wells, through the BPRC. The Panel fully supports on-going efforts in that regard.

5.8 Recommendations

The Panel believes that the following matters involved in the cause of the 13-12 blowout need further investigation. Many of these are already being looked at by the BPRC as a result of Phase 2 of the inquiry.

1 The following types of equipment should be examined for design, capacity, and operational problems to ensure that they are adequate for worst-case conditions:

    (a) degasser,
    (b) casing pressure instruments,
    (c) travelling block hook latch,
    (d) kelly hose,
    (e) blowout preventers, and
    (f) equipment for anchoring drill pipe.

2 The BPRC should examine the impact of H_2S, and how to avoid those impacts on:

    (a) drill pipe,
    (b) external BOP components, and
    (c) BOP master controls.

3 The industry and ERCB should take any action necessary to ensure that drilling operations are carried out in a cautious manner particularly in the critical zone of critical sour wells. Special procedures should be developed, documented, and used for operations in the critical zone. These would include detailed instructions respecting tripping in, tripping out, coring, testing, and other operations where particular care is required.

4 Standard kick-control procedures should be reviewed to determine whether they allow for situations where equipment failures or other unexpected events occur during control operations.

5 The adequacy of the current training programs for drilling personnel should be reviewed and particular consideration should be given to ensuring that they are effective in ensuring crew familiarity with kick recognition and control.

6 Consideration should be given to the need to have special expertise available while operations are being conducted in the critical zone of critical sour wells.

7 The ERCB should review its inspection system and in particular should conduct special inspections of critical sour wells immediately prior to entry of the critical zone and while drilling in it, to ensure that operations are being conducted in a cautious manner and consistent with proper procedures.

8 Mud system design and operation should be reviewed respecting density, system capacity, backup supply, scavengers, and impact of H_2S on mud and the ability to pretreat and recondition it.

9 Occupational Health and Safety (OH&S) should consider amending its regulations to ensure that breathing apparatus is available for all individuals that may be at a rig, including extra people called in for an emergency.

6

Heat-shielded tractors prepare the site for well capping operations.

Photo credit: W. Wylie, ERCB

6 WELL-CONTROL ACTIVITIES AND THE ADEQUACY OF ACTIONS BY AMOCO AND OTHERS

6.1 Introduction

Once a blowout has occurred, there are several factors which influence the length of time it will take to regain control. Appendix 3 of the Phase 2 report provides details of the 21 blowouts that have occurred in Alberta during the period 1974 to 1983. The duration of the uncontrolled flow of those wells ranged from a few hours to the 67 days for the 13-12 well. The average duration was about 10 days. There are, of course, major differences between the "characteristics" of the 21 blowout cases. One of the objectives of this section is to examine the factors that have the most influence on the difficulties involved in regaining well control and thus on the blowout duration. The section also examines the question of whether Amoco's actions while attempting to gain control were appropriate. The assessment is based upon information that was available to Amoco at the time of the blowout, rather than on knowledge gained as a result of it.

6.2 Blowout Characteristics

The characteristics of a blowout which have the greatest bearing on its duration are the magnitude of the flow, the H_2S and liquid content of the well effluent, the condition of the wellhead and blowout control equipment, and the weather or atmospheric conditions with which the well control specialists must contend.

A review of the blowout wells listed in the Phase 2 report indicates that the 13-12 well blowout generally exhibited characteristics which were among the most severe in terms of problems which had to be dealt with during control operations.

The 13-12 well was flowing gas at a very high rate, probably more than 1.4×10^6 m^3 per day, and this by itself would present problems in regaining control. The flow rate was not accurately estimated in the initial stages and efforts should be made to ensure that, in future situations, the most accurate estimate practical is made at an early stage. The high flow rate was also a direct reflection of the high pressure and the need for greater strength in the well-control equipment. The more serious aspects of the flow, however, were its high H_2S and condensate content. The very high H_2S content, estimated at the inquiry to be 25 per cent, not only posed a serious safety hazard to the on-site workers when the well was not on fire, but it also meant that all of the equipment used was subjected to very corrosive gas and liquids.

The estimated hydrocarbon liquid content of the gas was such that about 1100 m^3 per day of condensate may have been emitted. During the period the well was not burning, most of the condensate settled on the well site and immediate surrounding area creating a very dangerous and slippery environment in which the well-control operations had to take place.

The fact that the blowout had occurred through the drill pipe and that it had broken off above the floor also complicated control procedures and very much limited the type of action that could be taken. The presence of the drill pipe in the BOP stack prevented well control by closing the blind rams. At the same time, closing the pipe rams did not accomplish well control, as the well effluent continued to blow out through the drill pipe.

The process of regaining control of the well was also significantly affected by atmospheric conditions. Indeed, the weather appears to have been particularly important for the 13-12 well because of the high H_2S and condensate content. Unless there was a reasonably steady breeze to help clear the site of H_2S, it was not possible to work. During the period of the blowout, there were about 10.5 days when atmospheric conditions were unfavourable and prevented full activity.

Amoco was faced with a difficult well to control and the extreme characteristics of the blowout were clearly beyond Amoco's control once the well had blown out. The Panel questions, however, whether Amoco, and indeed other parties involved in the control operation, fully appreciated the magnitude of the problems. Evidence of this appears in the initial and on-going expectations that the well would be controlled in a matter of a few more days.

6.3 Appropriateness of Control Plans

Once a blowout has occurred, the most important factor in regaining control is the development and implementation of suitable control plans. Planning was particularly important for the 13-12 well because of its very difficult characteristics.

6.3.1 Emergency Response Plan

Amoco has a "Major Wellsite Incident Response Plan", which was activated on 17 October 1982 when the 13-12 well went out of control. The high H_2S content of the well effluent meant the situation was a Condition IV, which is the most extreme recognized in the plan. The response plan is not site-specific and so did not provide for specific measures to control the well. It did, however, result in immediate notification of senior Amoco personnel and the ERCB. Amoco then engaged a well-control specialist team, Wild Well Control Inc.

Within 48 hours of the blowout, Amoco had put together a group which included its own local people, Amoco's management personnel, wild well specialists from Amoco's parent organization, well-control specialists from

Wild Well, and safety and other service personnel. During the early period of the blowout, Nabors' personnel attended planning meetings. Alternative plans to cap the well were discussed and a preferred sequence was established. The group, along with ERCB personnel, met almost daily throughout the period of the blowout and continuously reviewed and updated the plans for control of the well. When critical procedures were to be carried out, detailed planning meetings took place to ensure that each individual knew his responsibility.

The Panel considers that the contingency planning as it related to control of the well and subsequent planning of the actual methods to be used was carried out reasonably well and co-ordinated in an acceptable manner between the operator, its control specialists, and the ERCB. Most of the serious problems encountered did not result from deficiencies in planning, although the chances of some of them occurring might have been modestly reduced with greater attention to detail in the planning process. Experience gained in this incident should be put to use in future situations and one valuable lesson gained is the need for extreme detail in planning the control procedures. The availability of medical expertise and advice would assist in ensuring satisfactory arrangements for breathing equipment, on-site treatment in the event of accidents, and evacuation procedures for workers.

6.3.2 Plan A

The initial plan to control the well, which is illustrated in Figure 6.1, involved lowering a new blowout preventer over the drill pipe and bolting it into place. It failed because an automatic pipe cleaner, the presence of which had been forgotten, was in place on the rig and it constricted the size of the available opening.

Failure to remember the pipe cleaner was an unfortunate human error which might have been avoided if the planning sessions had included all personnel previously involved with the rig and had incorporated a pictorial reproduction of every element of the rig. If the existence of the pipe stripper had been recalled, it would likely have reduced the duration of the blowout by a couple of days.

6.3.3 Plan B

The next plan involved opening the pipe rams in the BOP which were closed around the pipe in the hole. This would allow the pipe to drop, as Amoco expected would happen, or result in it blowing out of the hole because of pressure from the formation. The blind rams would then be closed to control the well as shown in Figure 6.2. When the pipe rams were opened, the pipe blew out of the hole, created sparks, and started the first fire. The blind rams did not close and Plan B failed. The reason the blind rams did not close is not known, but it may have been because the fire quickly destroyed the hydraulic hoses.

In the Panel's judgement, this method was appropriate to apply at that particular time, and even if it had been clear that the pipe would blow out, it would likely have been attempted. The use of flexible hose for the hydraulic lines and the short time which it took for the fire to destroy them was a problem, but not one primarily related to planning. Amoco and its specialists had carefully considered that matter and made the decision they considered best in the circumstances.

6.3.4 Plan C

The next plan is illustrated in Figures 6.3 and 6.4. It involved extinguishing the fire and lowering a new control assembly over the casing. The process was interrupted by an accident which resulted in the death of two workers. A critical seal in the control assembly was damaged during or following the accident. The damage was not noticed until 2 days later when control activities resumed. The well caught fire a second time before control procedures could be repeated with a new seal.

The Panel is satisfied that this was an appropriate procedure to attempt and that it was planned in some detail. It is possible however that greater detail in the planning and particularly a rehearsal of actions that would be taken in the event of a serious mishap might have reduced the seriousness of the problem. Safety matters are discussed further in section 6.4.

6.3.5 The Successful Plan

The well was finally controlled by lowering a new BOP assembly onto the casing and attaching it while the well was burning, as illustrated in Figures 6.5 and 6.6. This operation was carried out by Boots and Coots Inc.

There is no evidence to indicate that the change that Amoco made in its control experts for this final and successful capping attempt related to any lack of planning. Rather, Amoco had decided, as a result of damage to the casing bowl from the second fire and pressure from the public and the ERCB, that an attempt should be made to control the well while it was on fire. Such a procedure had only been successfully carried out six times in the world. Wild Well declined to attempt it and Amoco engaged a new specialist control team.

6.3.6 The Relief Hole Plan

An alternative plan involved drilling a relief hole as illustrated in Figure 6.7 and attempting to approach the wellbore of the 13-12 well just above the Nisku reef. Communication would then have to be established between the two wellbores. The flow would be stopped by injecting fluids through the relief hole into the 13-12 wellbore. Experience at other wells has shown this method of well control is not always successful. A surface lease was prepared but drilling of the well was not initiated.

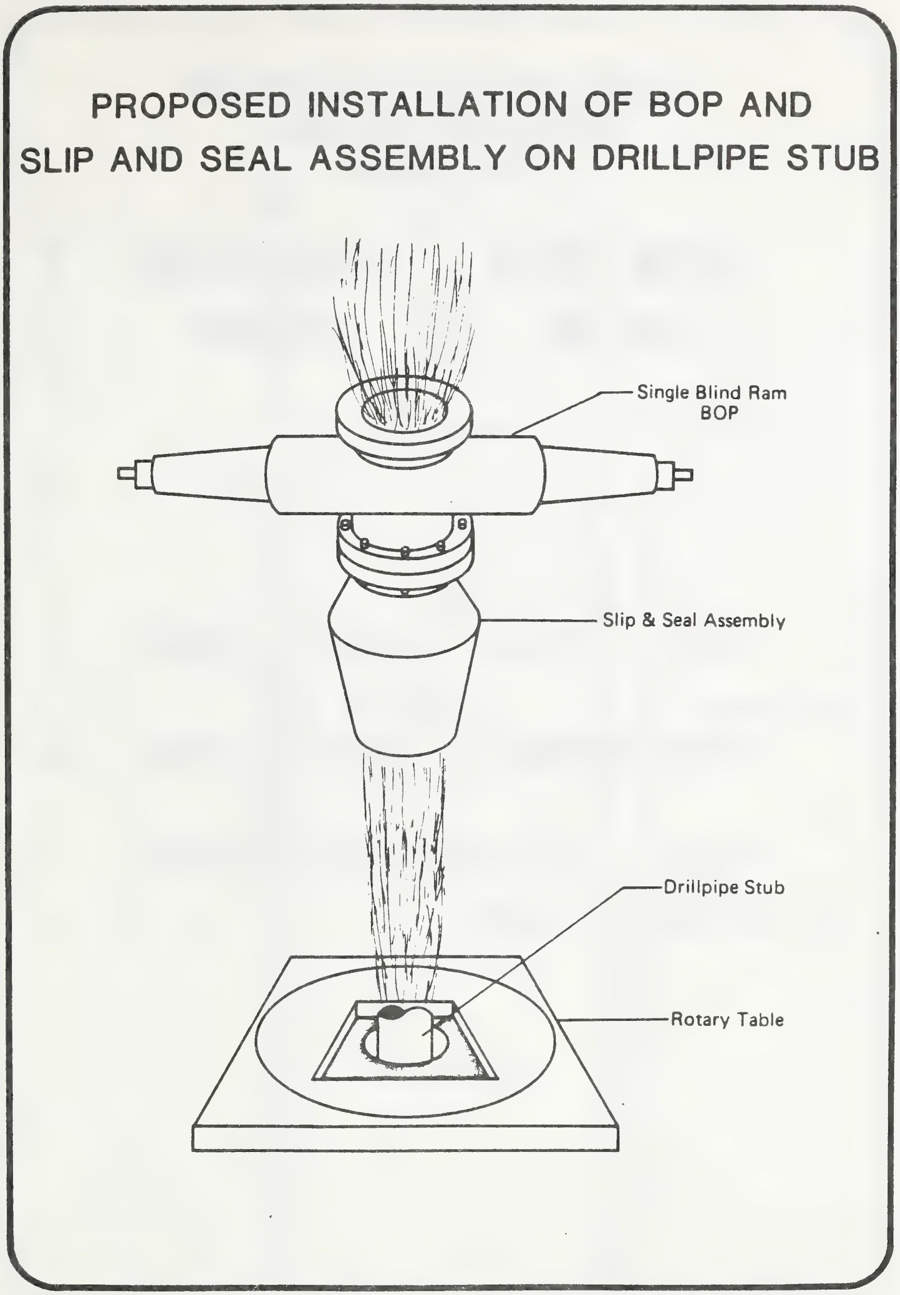

PROPOSED INSTALLATION OF BOP AND SLIP AND SEAL ASSEMBLY ON DRILLPIPE STUB
Single Blind Ram BOP
Slip & Seal Assembly
Drillpipe Stub
Rotary Table

FIGURE 6.1 AMOCO'S DIAGRAM OF PROPOSED INSTALLATION OF BOP (PLAN "A").
Reproduced from Exhibit No. 66.

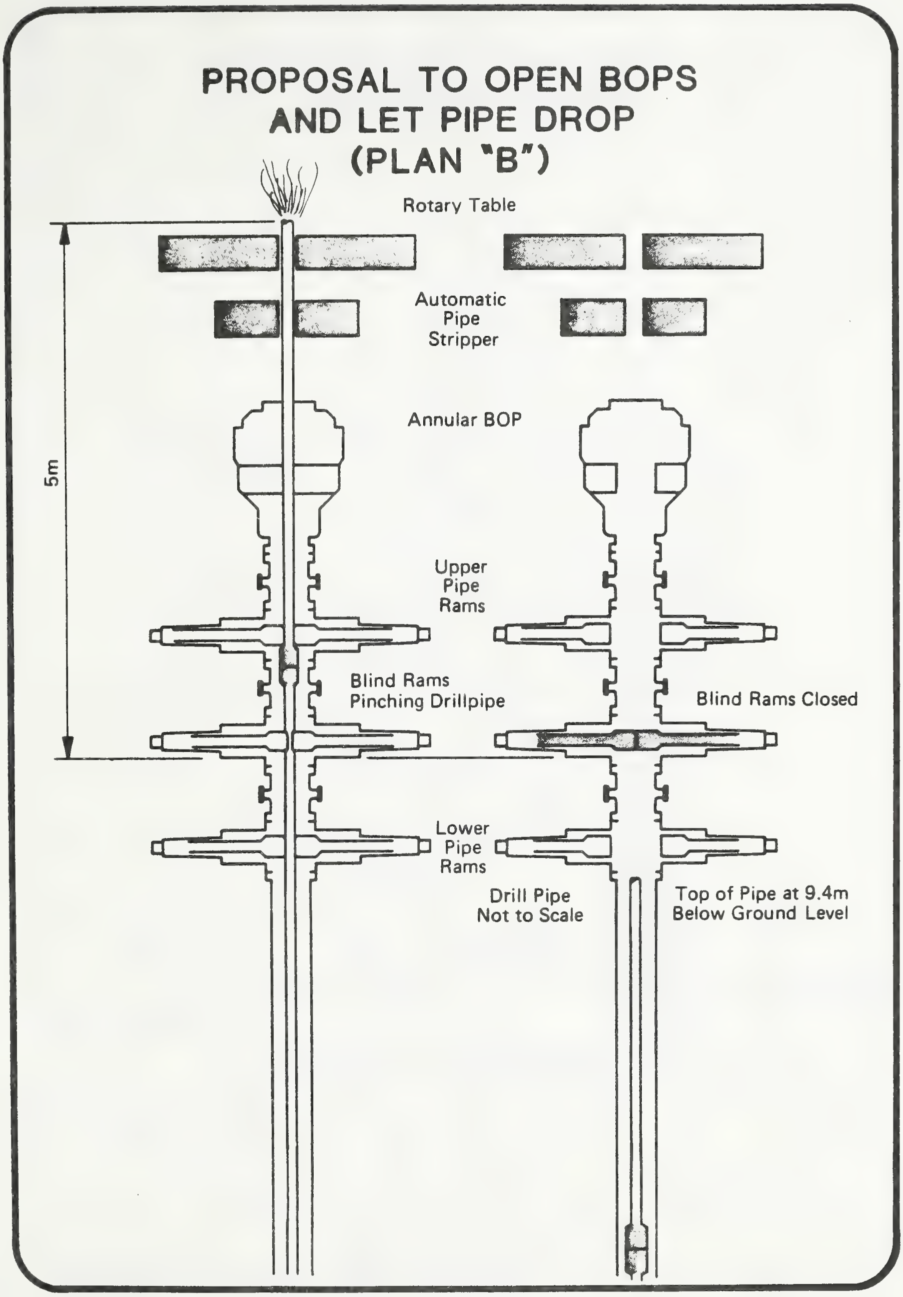


FIGURE 6.2 AMOCO'S DIAGRAM OF PROPOSAL TO OPEN BOPS AND LET PIPE DROP (PLAN "B"). Reproduced from Exhibit No. 66.

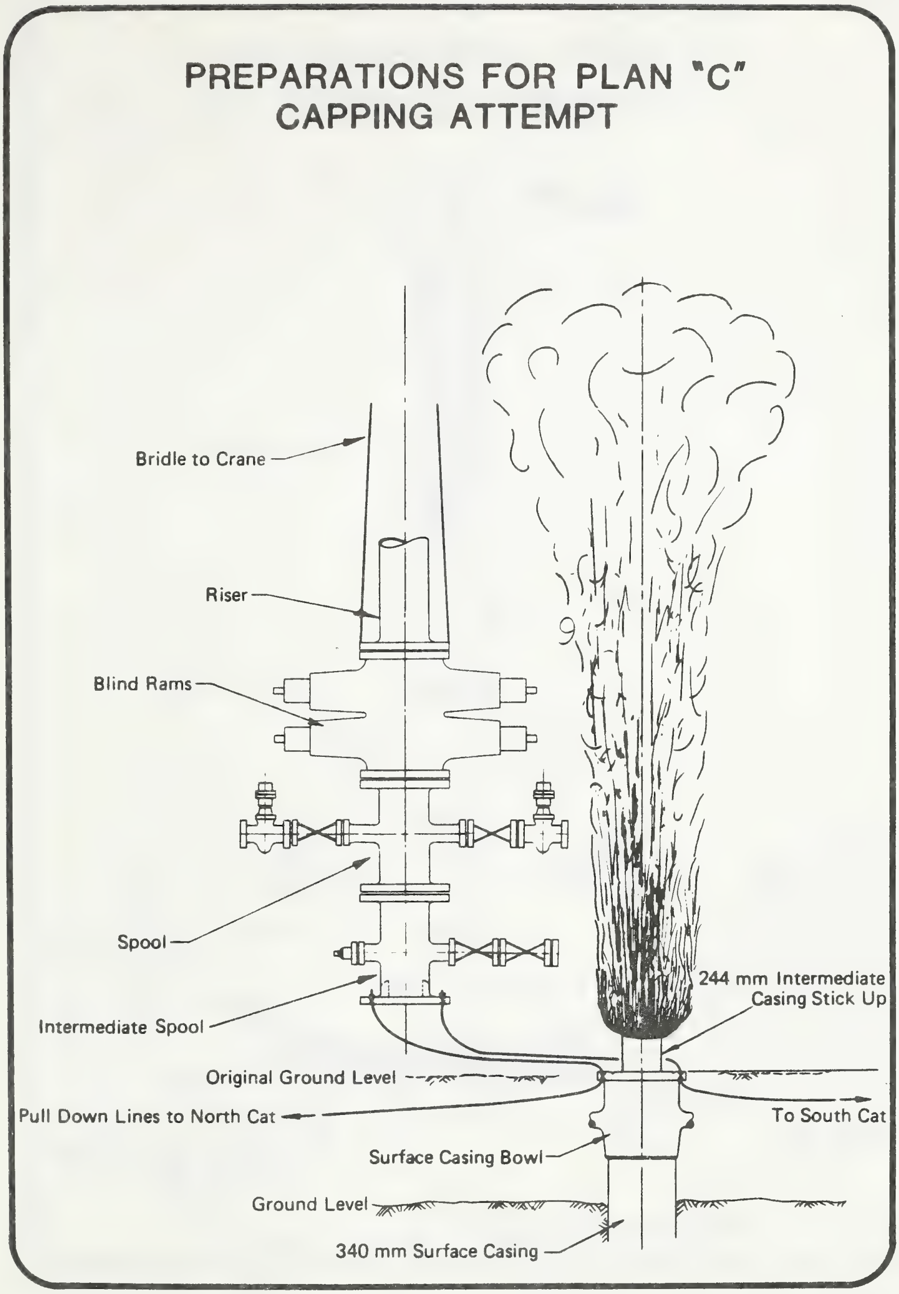


FIGURE 6.3 AMOCO'S DIAGRAM OF PREPARATIONS FOR PLAN "C" CAPPING ATTEMPT.
Reproduced from Exhibit No. 66.

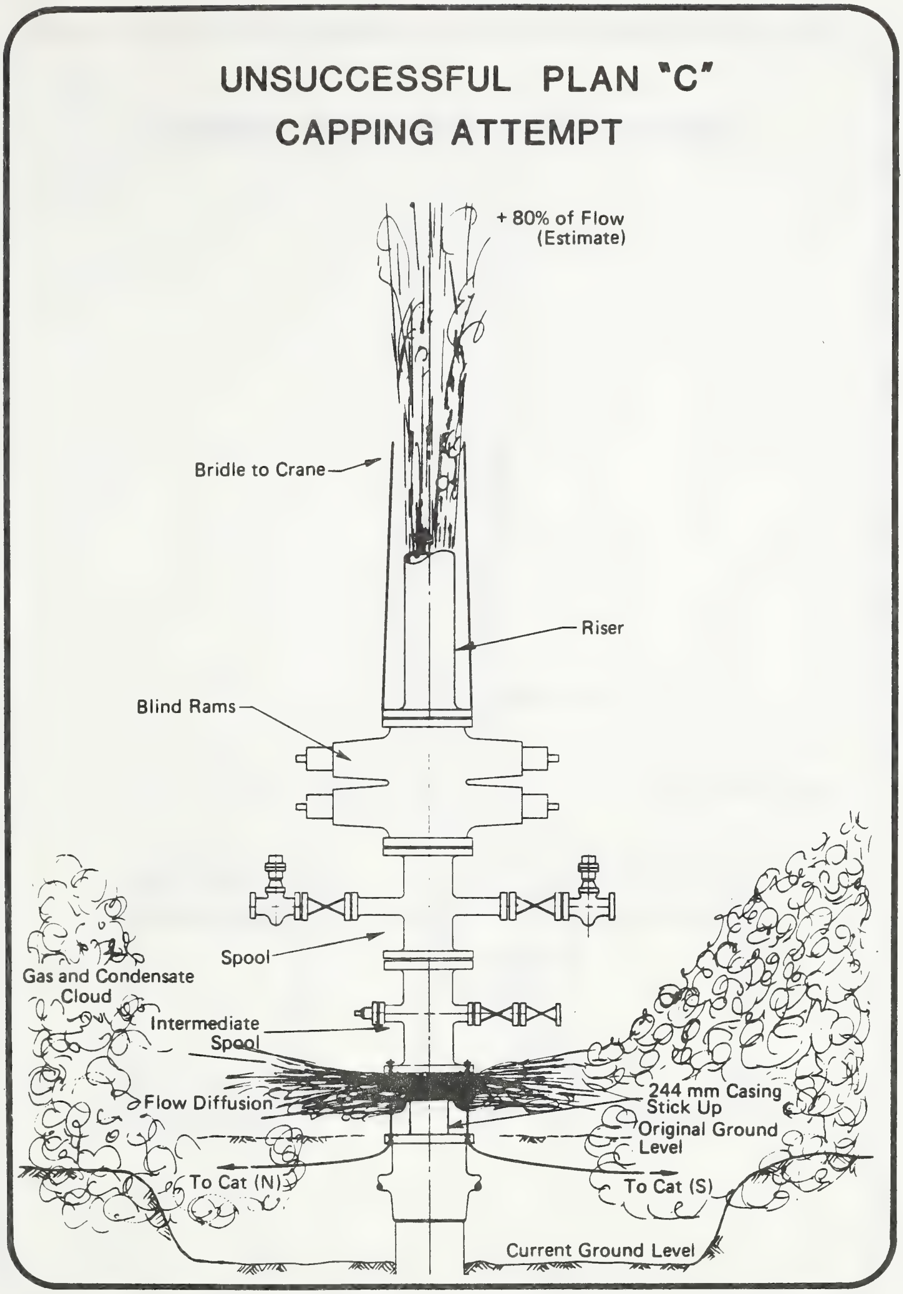


FIGURE 6.4 AMOCO'S DIAGRAM OF UNSUCCESSFUL PLAN "C" CAPPING ATTEMPT.
Reproduced from Exhibit No. 66.

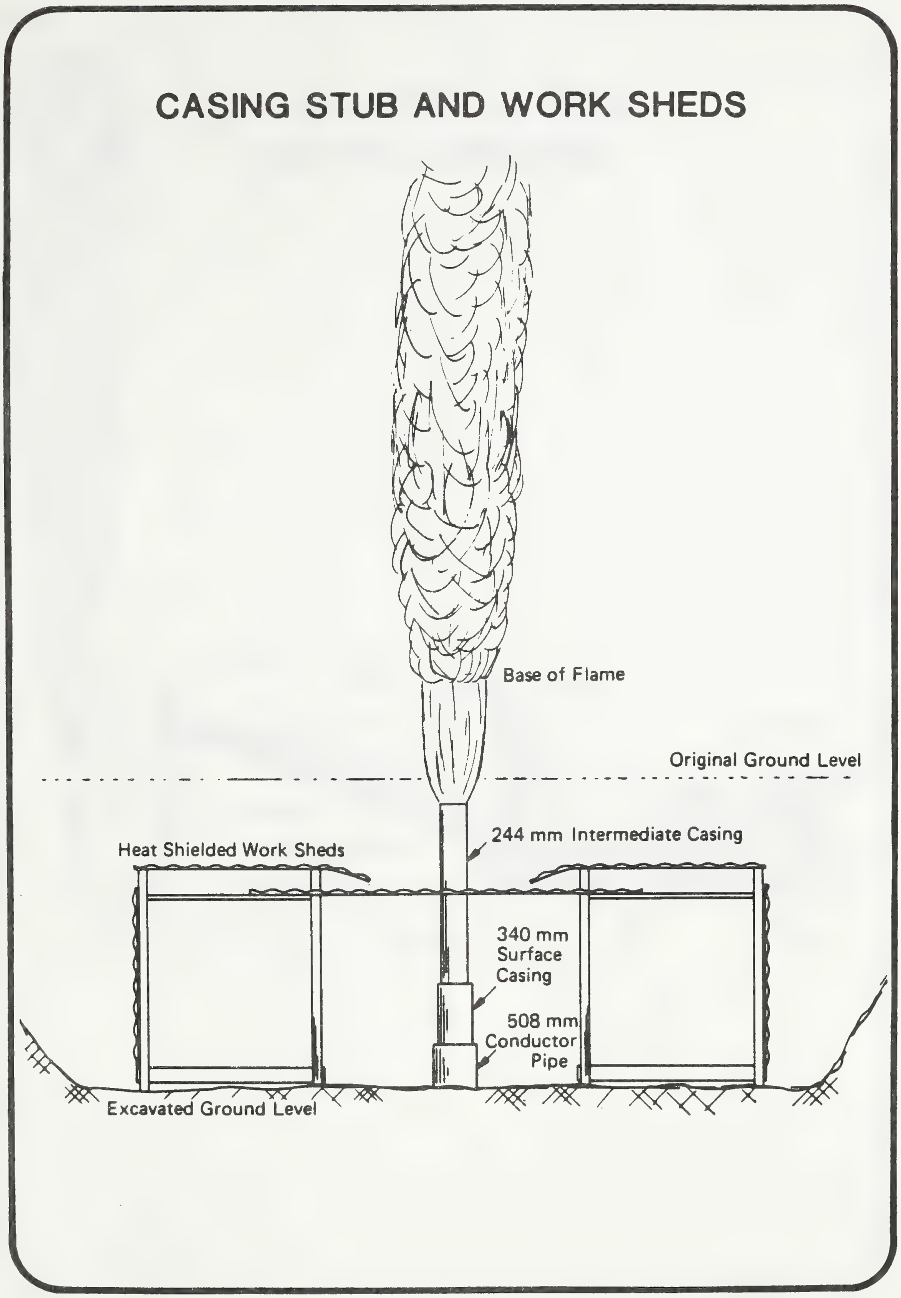


FIGURE 6.5 AMOCO'S DIAGRAM OF CASING STUB AND WORK SHEDS.
Reproduced from Exhibit No.66.

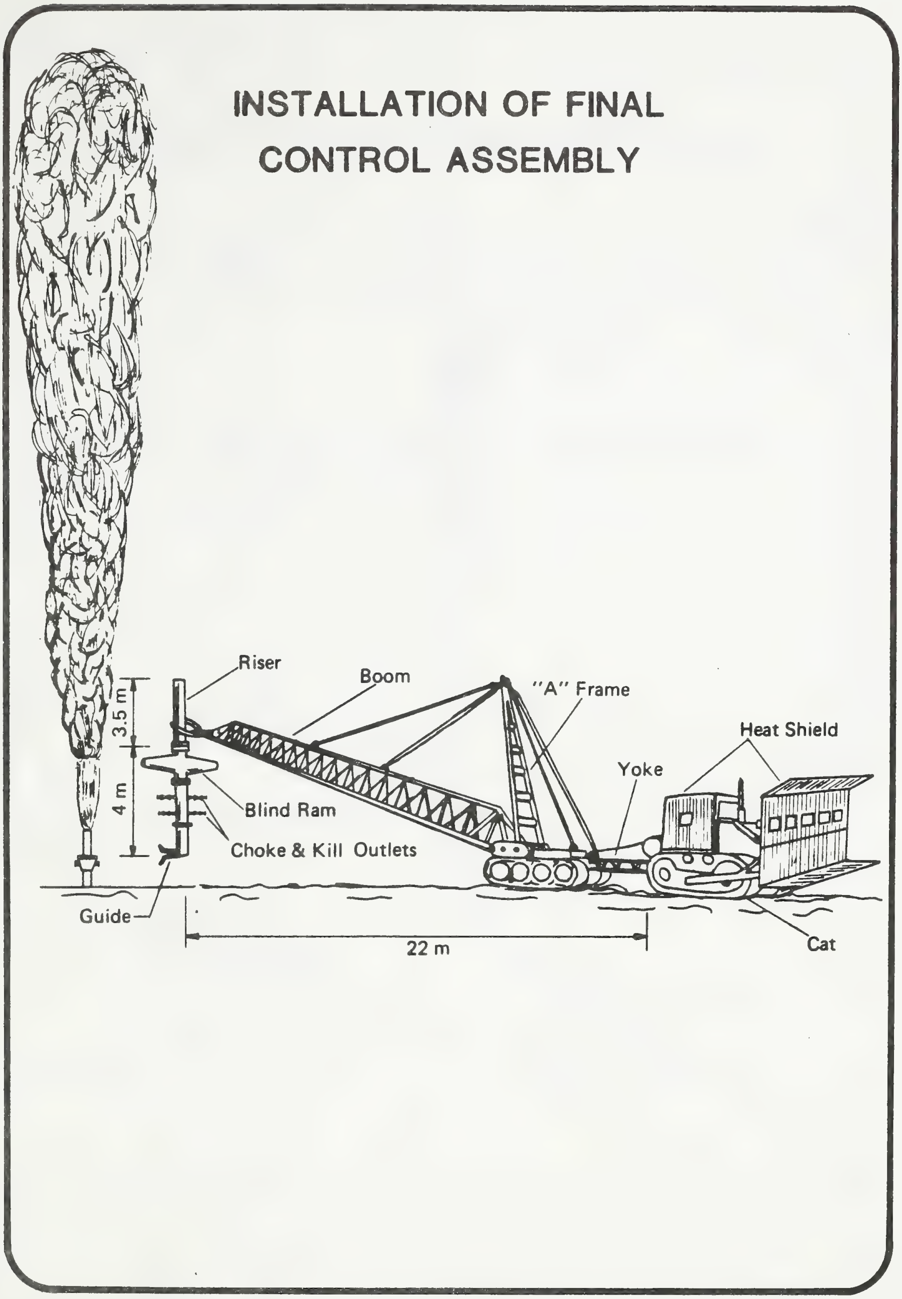


FIGURE 6.6 AMOCO'S DIAGRAM OF INSTALLATION OF FINAL CONTROL ASSEMBLY.
Reproduced from Exhibit No. 66.

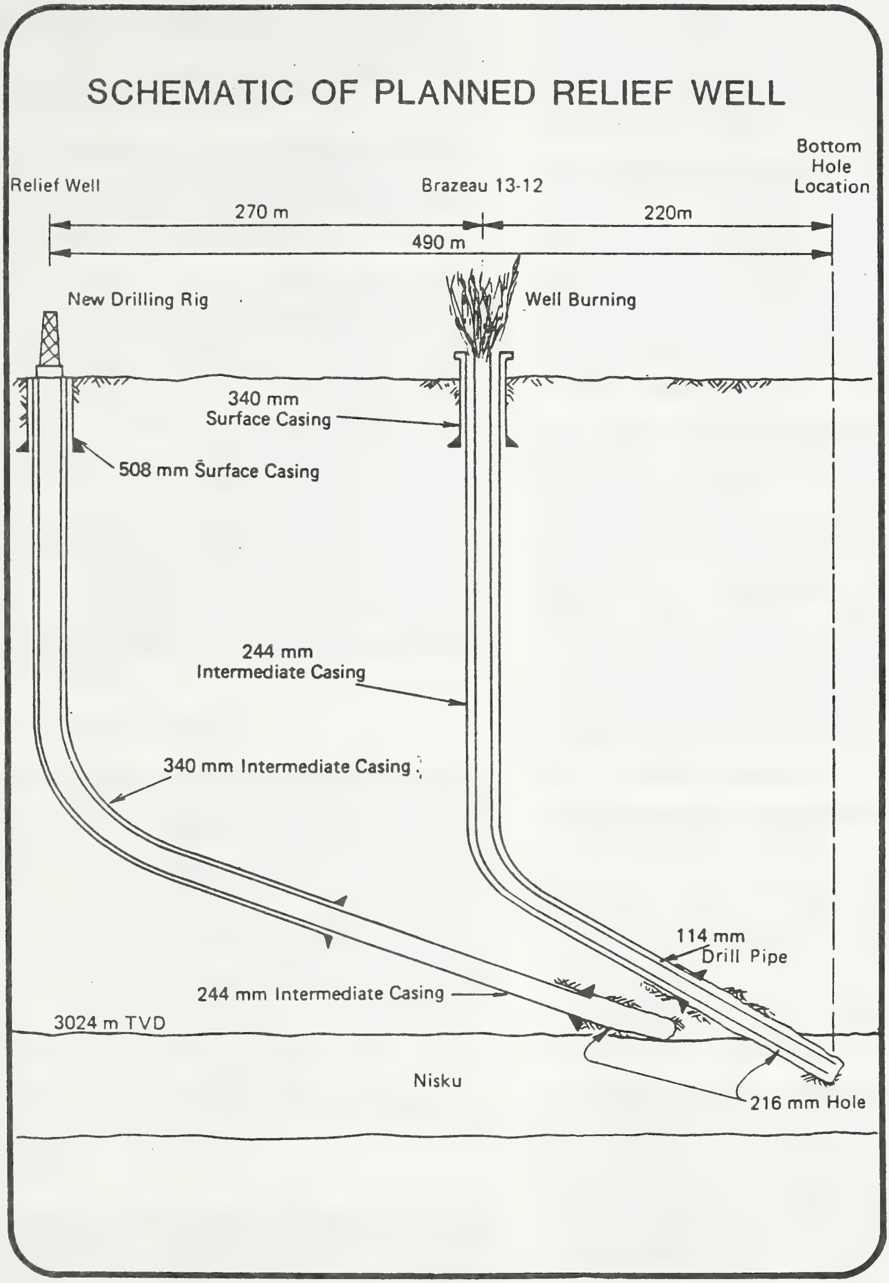


FIGURE 6.7 AMOCO'S SCHEMATIC OF PLANNED RELIEF WELL.
Reproduced from Exhibit No.146.

Amoco's position respecting the relief hole was that it should be a last resort because it would take up to 3 months to drill and then the chance of success was not as good as for a kill from the surface of the wild well (top kill). Amoco, however, prepared a site and placed a rig on standby for the drilling of the relief well.

Amoco contended that once the drilling of the relief well had commenced, top kill attempts would have to cease because the 13-12 well would have to be on fire for the safety of the men on the relief hole rig.

The Panel believes, on the basis of the evidence before it, that the ERCB's role in the decisions respecting the relief hole should be more formalized. The Panel is satisfied that ERCB representatives were aware of, and in accord with, the on-going decision not to proceed with the relief hole throughout the duration of the incident. Consideration should be given, however, to putting in place a process whereby the need for drilling a relief well would be reviewed on a detailed basis if a top control method proved unsuccessful, and to documenting in detail the reasons for the decisions. The process should also ensure that the decision makers are fully aware of the impacts the blowout is having on the public so that this aspect may be fully considered along with others. This matter is discussed further in section 6.3.7.

6.3.7 Igniting the Well

Amoco stated that it did not intentionally ignite the well because there was not a serious hazard to the public and igniting the well would have significantly reduced the chances of accomplishing a successful top kill in a short time period. The Panel agrees that at the time the decision was being made there was reason to believe this to be the case. The Panel does not believe the immediate ignition of the 13-12 well was necessary, however, it does consider that in certain circumstances ignition should take place. Such a circumstance could have occurred if H_2S levels had reached evacuation limits at Drayton Valley, where evacuation, due to the number of people, was not practical. The evidence suggests that the well would have been ignited if there had been any serious potential hazard to the town.

Although the Panel accepts that igniting a well would typically make it more difficult to effect a top kill and would present a more serious safety risk to on-site workers, it notes that the 13-12 well was eventually controlled while on fire. The success in this instance, along with the increased difficulties and risk, must be balanced if future blowouts result in a situation where the need to ignite a well, for public safety or comfort reasons, is being considered.

The Panel, in the Phase 2 report, recommended that the ERCB require an emergency response plan for all critical sour wells and that the plan deal with the manner in which the decision would be made as to whether a blowout should be ignited. This recommendation is affirmed and should assist in ensuring that the matter of intentionally igniting a well will be adequately dealt with in future.

As was the case with respect to the relief well, the Panel believes that the ERCB involvement in decisions not to ignite the well was not as formalized as it might have been. The Panel believes that in future, the ERCB should establish a formal review process that would consider the merits of igniting the well, throughout a blowout episode, and document the reasons for deciding whether or not to do so. In making this decision, all aspects of the matter, including impact on the public, must be considered.

The decision process respecting ignition, and also that respecting a relief well, must include an opportunity for the public to make their concerns known. The manner in which this would be done is important because it must allow for timely on-going decisions. The Panel recommends that the ERCB and other involved parties, in formulating plans for handling possible serious blowouts in future, consider this matter carefully and properly provide for public input. The system must also ensure that decisions respecting intentional ignition of a well or drilling a relief well are made known to the public along with the rationale for the decisions reached.

6.4 Control Equipment

A successful control operation requires specialized equipment to be promptly available.

Amoco was able to have on site all of the equipment necessary to control the well essentially when it was needed. This was possible, in part, because Amoco is a large international organization and was able to call on tremendous resources to assist. For example, Amoco had its own aircraft fly in necessary equipment from areas as far away as the Canadian East Coast and the Beaufort Sea.

One equipment problem which did occur resulted from the need to establish a new BOP master-control station at the edge of the lease because the original station was in the doghouse and had been exposed to high levels of H_2S. The station was needed for the control Plan B which involved opening the pipe rams to drop the pipe and then closing the blind rams.

The new station made it necessary to install new hydraulic lines to the BOPs and the decision was made to use flexible hose for ease of handling in the slippery and dangerous atmosphere under the substructure. The lines failed almost instantly during the ensuing fire and the blind rams did not close. However, it is not known for certain that the failure to close was as a result of the hydraulic lines burning quickly. In any case, the Panel is satisfied that the rationale used by the control experts in their choice of line was reasonable in the circumstances. This is an area where the experience gained in the Lodgepole incident may be of assistance if similar situations arise in future.

The Panel is satisfied that appropriate equipment was brought in or fabricated as required, promptly and without regard to cost, and that Amoco used whatever was needed of its considerable resources and international organization to obtain equipment. Indeed, the Panel, having heard much evidence respecting the resources that Amoco was forced to call upon in an effort to control the well and handle other aspects of the blowout, is concerned that a small organization, if faced with a similar situation, might not be able to handle it adequately. For this reason, the Panel believes the ERCB should consider the availability of blowout insurance or other measures which would safeguard the public purse against having to cover the costs of a major blowout. Consideration should also be given to ways in which the experience and expertise which a major company is able to bring to bear, because of its extensive operations, could be made available if a small organization experienced a serious blowout.

6.5 Safety Equipment and Procedures

The control operations required not only specialized control equipment and expertise, but due to the extreme hazard that resulted from the high H_2S and condensate content, on-site safety matters also played a key role in the operations.

Amoco stated that immediately following the blowout, it engaged the services of safety experts. Safety personnel were at the site at all times and they decided, on the basis of weather conditions and H_2S monitoring results, when control operations could be carried out. The position of Amoco was that safety aspects of the operation were effective notwithstanding that a serious accident occurred on 16 November.

The Panel is of the view that it was proper for Amoco to contract for the services of safety experts although Amoco had the final responsibility for the safety of the workers. The safety procedures apparently worked for most of the blowout period. However, there was a serious accident which resulted in the death of two workers, during an attempt to cap the well on 16 November. During this accident, three other men were rendered unconscious, and two more were affected by the gas. This clearly was a failure in terms of the safety system and brought out serious fundamental deficiencies in it. One of the deaths was the subject of an inquiry under the Fatality Inquiries Act and consideration of the deaths themselves was excluded from the terms of reference for the inquiry being dealt with in this report. However, the Panel believes it is impossible to consider "all aspects of occupational health and safety but excluding the two fatalities" without giving some recognition to safety equipment and procedures in use when the accident occurred. It has therefore drawn on the fatality inquiry evidence, which is on the public record, for that purpose.

The inexplicable removal of a breathing mask by at least one worker who was killed and the contamination of the masks of other workers raises the question of the leakage of gas into the face piece of the demand masks which were used. Although these masks met the requirements of OH&S, they had only a protection factor of 50. It is known that the death of humans can occur quickly at H_2S concentrations of 1000 to 1500 ppm, and that the concentration of the gas flowing from the 13-12 well was about 25 per cent or 250 000 ppm. Thus, when the upward rise of the gas was deflected, if air mixing was not sufficient to dilute the H_2S at ground level, the maximum protection factor of 50 would be exceeded. It is noteworthy that positive pressure breathing type masks have been recommended by the National Fire Protection Agency since 1981. Following the accident, OH&S ordered that masks with a positive pressure air supply be used in place of the demand type. Amoco's Major Wellsite Incident Response Plan, in reference material API Recommended Practices API RP 49, section 8.2(a), recommended the use of "pressure demand" masks. It may be that some confusion of the meaning of this term had some effect on the selection of the inadequate "demand" masks by Amoco for use in the capping operations.

The actions which several workers took, or were compelled to take, during the accident were not in accord with generally accepted safety procedures. Most striking was their inappropriate use of the 5-minute escape bottles created by the stress of the accident. Another safety problem which occurred during the 16 November accident related to the apparent inability of those on site to evacuate stricken workers from the extremely treacherous and high hazard zone within 20 or so metres of the wellhead. This might have been avoided by detailed planning of every aspect of a possible emergency situation. Such planning would have to include an exploration of methods for dragging unconscious men in prevailing slippery conditions, a system for communication in a gas cloud, the need for safety lines or dragging sheets, and the appropriate use of emergency air bottles for carrying out rescue.

Prior to 16 November, safety planning for possible emergencies did not deal with the kinds of details mentioned above. There is no evidence that this occurred to save time or money. Detailed written safety procedures were developed and implemented before work at the well site resumed following the 16 November accident. The

Panel believes that these procedures must be reviewed for possible improvement. In addition, the appropriate safety roles of government, industry, and safety specialists should be examined further.

6.6 The Human Factor

The human factor played a role in many of the matters dealt with earlier in this section. The Panel believes it worthwhile, however, to make a further comment respecting this factor.

The personnel involved in the efforts to control the well included Amoco workers, some Nabors people, the well control specialists, and other service personnel under contract to Amoco. The Panel is satisfied, that overall, these individuals were adequately trained and had experience consistent with their role in the process.

Some media reports at the time of the blowout suggested that Amoco's replacement of the well control team was a tacit admission that it had been mistaken in the first instance by engaging an inexperienced team. As indicated previously, the Panel heard no evidence to support that position and accepts Amoco's explanation that Wild Well was replaced because it was not prepared to cap the well while it was burning.

6.7 Summary of Panel's Views

The overall general contingency plan which Amoco had in place was satisfactory. Although the plan was not detailed nor site-specific, it worked reasonably well for well-control operations because it brought together those persons who had the knowledge and the authority to implement any action necessary. The plan also generally identified the responsibilities of each party and provided for an on-going planning process which was well co-ordinated and generally effective in most respects. One notable exception was lack of sufficient detail in establishing Plan A, and thus overlooking the existence of the automatic pipe cleaner on the rig. In addition, there is clearly a need for a site-specific emergency plan for critical sour wells. This is discussed in section 7.5.

It took 67 days to control the 13-12 blowout primarily because of the well's characteristics which were particularly severe. They included a very high flow rate with very high H_2S and condensate content which, when coupled with unfavourable weather conditions over part of the period of the blowout, resulted in a dangerous and difficult working environment for those attempting to control the well. These matters were beyond Amoco's control but there are indications that the seriousness of them was not fully appreciated by Amoco and others, including the ERCB. An illustration of this related to safety matters where Amoco employed equipment and procedures which appeared to be typical of the industry. In this case, because of the very severe conditions, a serious accident occurred which substantially delayed capping of the well.

The panel is satisfied that Amoco demonstrated a full commitment to the task of restoring control at the well. There is no evidence that any of its decisions were governed by costs or factors other than an intent to control the well as soon as reasonably possible. It is true that several attempted procedures did not succeed, and indeed a combination of unfortunate occurrences meant that the blowout extended for a much longer period than would normally be expected.

The initial and on-going decisions not to intentionally ignite the well, and either attempt to cap it while on fire or proceed with the actual drilling of the relief well, were appropriate given the circumstances that existed. However, the involvement of the ERCB in those decisions might have been more formalized and it should have given more specific attention to impacts which were occurring on the public. A system is needed to ensure that all aspects of such decisions, including impact on the public, are carefully considered and that the decision and supporting reasons are communicated to the public.

The Panel is concerned that a small organization experiencing a similar blowout might not have the resources and expertise that Amoco was able to mobilize for the 13-12 well blowout. Therefore, it believes the ERCB should investigate this matter further, including the feasibility of requiring blowout insurance.

The Panel is generally satisfied that the personnel involved in efforts to control the well were properly trained and that they had the appropriate experience to undertake the necessary operations. However, it is not satisfied that Amoco's planning process was sufficiently detailed with respect to occupational health and safety, particularly as it related to handling extreme emergency situations. Additionally, the Panel is concerned that the role of OH&S was not sufficiently pro-active during planning of the control procedures. The Panel believes that further work is required by government and industry to ensure that safety matters are adequately dealt with in similar future situations should they occur.

6.8 Recommendations

After considering the evidence respecting efforts to control the well, the Panel makes the following recommendations:

1 The ERCB and the involved operator should make a serious effort at the outset of any blowout to ensure that the flow rate and other characteristics are estimated as accurately as possible, and that the estimates and the expected weather conditions are properly recognized in planning for control of the well.

2 The ERCB should formalize, to a greater extent, its involvement in decisions related to intentionally ignit-

ing blowouts and the possible drilling of relief wells. A process should be developed that would ensure that public concerns are properly considered in making these decisions, and the reasons for the decisions are communicated to the public.

3 OH&S should give consideration to the establishment of a committee to be concerned with protecting workers in toxic gas environments such as would result from episodes like the 13-12 blowout. Such a committee might be composed of experts on safety and rescue drawn from OH&S, the petroleum industry, the ERCB, and the Calgary and Edmonton fire departments. These individuals, or a team which they could assemble, could be readily available to act as advisers or participants in the management of the safety aspects of particularly dangerous situations in the petroleum industry. With respect to the prevention of serious accidents, they could assist in reviewing current and future safety and rescue practices and safety educational programs.

4 OH&S should give consideration to the development of an adequate, possibly compulsory, training program for workers who might encounter H_2S or other toxic gases in substantial amounts. The training would be needed prior to their involvement at a well site or other potentially dangerous locations. This training should emphasize practical matters such as familiarization with and the wearing of a self-contained breathing apparatus. Through such a program, workers who are physically or psychologically unsuitable for work in such hazardous environments, or while wearing masks, would likely be identified.

5 The ERCB should investigate the availability and limitations of blowout insurance. The Panel understands that the matter of insurance is being looked at by the ERCB as a result of the Phase 2 report.

6 The ERCB should consider how the experience and expertise needed to control a blowout would always be available when required, even by a small organization.

7 OH&S should pursue the development of clearly distinguishable names for all types of masks to be used in the presence of various concentrations of H_2S.

8 Consideration should be given by industry and the ERCB to the development of a workshop or seminar to consider technical matters related to the control of wild wells.

7

Alberta Environment's mobile air monitoring laboratory.

Photo courtesy Alberta Environment

7 HAZARD TO HUMAN HEALTH

7.1 Introduction

One of the issues of primary concern to the public, particularly those residing in the immediate area of the well, was the effect of the blowout on their health. Evidence respecting health effects was presented by some of the local residents and by a group of Edmonton respiratory patients. Additionally, studies were presented which were conducted by various groups or individuals to learn about the concerns of larger segments of the public. There was considerable discussion at the inquiry respecting the standards and suitability of H_2S exposure limits. The question of how the monitoring was carried out and whether those standards were exceeded also received much attention. This section of the report reviews each of these matters.

7.2 Medical Evidence

The Panel was not presented with any medical studies, and only one veterinary medical study of the effects of the Lodgepole blowout which could be considered to be scientific, because scientific data was not available to compile such studies. Furthermore, there are few epidemiological studies in the medical literature which are applicable to the affected local and distant communities. Nevertheless, a great deal of other information was presented bearing on the health of people and animals in areas close to Lodgepole.

7.2.1 General Effect on Local Population

The most useful medical data was given by 30 residents, mainly from farm families widely separated from each other within 50 km of the blowout site. The location of their residences is shown on Figure 7.1. They described the effect of this event on themselves and their families, and said their symptoms had an onset coincidental with the blowout. These included headache, eye irritation, upper respiratory tract symptoms such as sore throat, nasal irritation, and nosebleeds in children, lower respiratory tract symptoms including pain on deep inhalation and some shortness of breath. Gastrointestinal problems such as loss of appetite, nausea, and diarrhea were also described. An interpretation of these symptoms suggests that some could be related to irritation of exposed mucous membranes or gastrointestinal dysfunction, while other symptoms such as headache cannot be identified with dysfunction of one organ system.

These complaints were said to improve within 24 hours in people who left the area and recurred within 24 hours when the same individuals returned during the time of the blowout. When the well was on fire, some people recalled improvement while others reported that they suffered persistent symptoms. Complaints suggestive of central nervous system dysfunction were infrequent. During cross-examination, some of these individuals denied symptoms such as chills, generalized muscle aching, or some of the usual systemic complaints of an acute infectious process. PASGEC filed letters from three physicians describing similar symptoms during this period in patients from the same general area. These physicians attributed these medical findings to the gas in the environment. They did not make any assertions with respect to permanent symptoms or harm.

An attempt was made by the Panel to determine how representative this small group would be of the entire community. It is possible to group 20 of the individuals who appeared, representing 17 families, into a region north and east of the Lodgepole blowout. They would constitute about 7 per cent of the population. To determine how representative these witnesses were of the entire community population of 244 families, the Panel reviewed data from the WIN report. In this questionnaire study of the area residents comparing the frequency of symptoms experienced before, during, and after the blowout, the investigations showed a large increase in the number of people complaining of the previously discussed symptoms. This was not analysed statistically in the report and was used by the Panel only for the limited purpose of checking on how representative were the complaints of this small group of area residents who gave testimony. The residents came from Buck Creek, Cynthia, Drayton Valley, Easyford, Lodgepole, and Violet Grove areas.

7.2.2 Special Groups of Patients

Because of the lack of data, it was very difficult to assess the effect of the blowout on groups which might be expected to be at special risk, such as those with acute or chronic respiratory disease, individuals who are chronically ill, or small children. Two of the PASGEC witnesses, with previously diagnosed emphysema, said that they were considerably affected and the asthmatic husband of a third was described as incapacitated. The Panel accepts that such descriptions were probably accurate.

In the regions remote from the area of the blowout, even less health information was available. A retrospective chart review on 60 in-hospital patients and out-patients with chronic respiratory disease in Edmonton was performed by Dr. Neil Brown and colleagues. Because of inherent limitations in the design of the study, no firm conclusions can be drawn except to note that these patients had complaints during the period in question. Unfortunately, the time periods evaluated before and after the blowout were unequal and could not be fairly compared.

An important consideration is that although the H_2S was at very low levels in the Edmonton area (a maximum of 0.521 ppm), its odour was frequently evident. Since olfactory stimulation may cause a reflex contraction of smooth muscle in the tracheobronchial tree, it is possible that odour without irritation could have affected individuals in the Edmonton population who had increased airway reactivity from such diseases as asthma, chronic bronchitis, and emphysema. If this did occur, no permanent effect would be expected. Since 1477 complaints were made to Social Services and Community Health (SS&CH), 1187 from Edmonton residents, one can conclude that the odour was unpleasant for many healthy individuals as well.

7.2.3 Exposure to Low Levels of H_2S

Evidence was presented about Rotorua, New Zealand, a small community where residents are frequently exposed to H_2S from sulphurous hot springs in the area. Sporadically, the H_2S collects at levels which, on occasion, have even caused fatalities and this is understandable since the visitors from the Amoco medical team themselves recorded very high levels around holes or springs close to the ground. The Panel understands that the authorities do not monitor continuously for low level H_2S concentrations in Rotorua and have never conducted scientific health studies on the subject. Thus, the speculation that H_2S is well tolerated at low levels cannot be scientifically evaluated on the basis of their experience. A formal, well-conducted study including environmental monitoring might have been very useful and possibly could still be performed.

Dr. Smith, appearing for Amoco at the inquiry, argued that chronic low-level exposure to H_2S is not harmful based on the following two points. He drew an analogy between H_2S and the salts of cyanide, the latter of which has a low chronicity factor in animals. Cyanide, like H_2S, affects the enzyme cytochrome c-oxidase, thus disturbing critical electron transfer systems in the metabolism of cells. Secondly, he quoted from an abstract of recent experiments using mice and rats, which had been recently presented but not yet published. While these animals were exposed to 10, 30, and 80 ppm of H_2S for 90 days, lesions were seen only at 80 ppm. With the exception of the latter study, Dr. Smith's comments about H_2S were focused on systemic toxicological effects rather than the pathophysiological consequences to the respiratory system. Dr. Smith conceded that enzyme systems other than cytochrome c-oxidase were affected by H_2S.

In discussing these results, Dr. Clanachan of the University of Alberta noted that results drawn from experimentation with cyanide might not be analogous to H_2S, despite the fact that both of these affect cytochrome c-oxidase. He also pointed out that animals treated with injections of sodium sulphide might be differently affected by inhalation of H_2S because of the different ionization characteristics of sodium sulphide. Dr. Clanachan also cited experiments on goats exposed to 10 ppm of H_2S for 1 day which caused loss of appetite and reduced water intake.

7.2.4 Illness in Animals

The Panel decided to comment here on the problems of animal health because of the many similarities in signs, particularly related to respiratory problems, common to both people and animals resident in the Lodgepole area during the blowout.

Many of the 30 local area residents referred to problems with their farm animals during the blowout period. They noted these animals suffered from runny eyes and noses, coughing, and decreased food intake. There were striking descriptions of most of the members of the cattle herds being affected, the young animals more than the older ones. Residents also testified that animals suffered diarrhea, red stools, red urine, and decreased weight gain. Members of five families mentioned the almost total disappearance of birds or small animals which did not reappear for a long time after the blowout was controlled.

Dr. Josephson, a veterinarian in private practice in the area, described the animals as commonly having respiratory and ocular irritation and decreased food intake. She stated that their temperatures were normal despite the signs. In animals with pre-existing respiratory trouble, there were unsatisfactory and unusual responses to antibiotic treatment during the time when the well was blowing but improvement during the period of flaring.

The Panel accepts that the high rate of ocular and respiratory symptoms reflecting mucous membrane irritation in different species of animals simultaneously and the disappearance of birds and small animals was unique and cannot be explained on the basis of natural causes. It is much more difficult to interpret the descriptions of gastrointestinal illnesses in animals since these are known to occur in the absence of atmospheric pollution.

Representatives of Alberta Agriculture (AA) testified that they perceived their role in such incidents as the Lodgepole blowout as that of responding to requests for assistance from the farm community.

Representatives of AA did not visit the Drayton Valley area until 2 December when they went to three farms over a 1-day period, 1 week after the well was accidently ignited the second time. No epidemiological studies were performed. The local District Agriculturist said he contacted local veterinarians who did not report unusual livestock problems. It is noteworthy that many people, with domestic animals which suffered illnesses, stated that they had not communicated with AA, but either relied on local veterinarians or did not complain at all.

The claim that air pollutants caused spontaneous abortions in livestock and other animals was made by several farm witnesses. AA presented a review showing no increase in the rate of spontaneous abortions in west central Alberta compared to elsewhere in the province or to previous

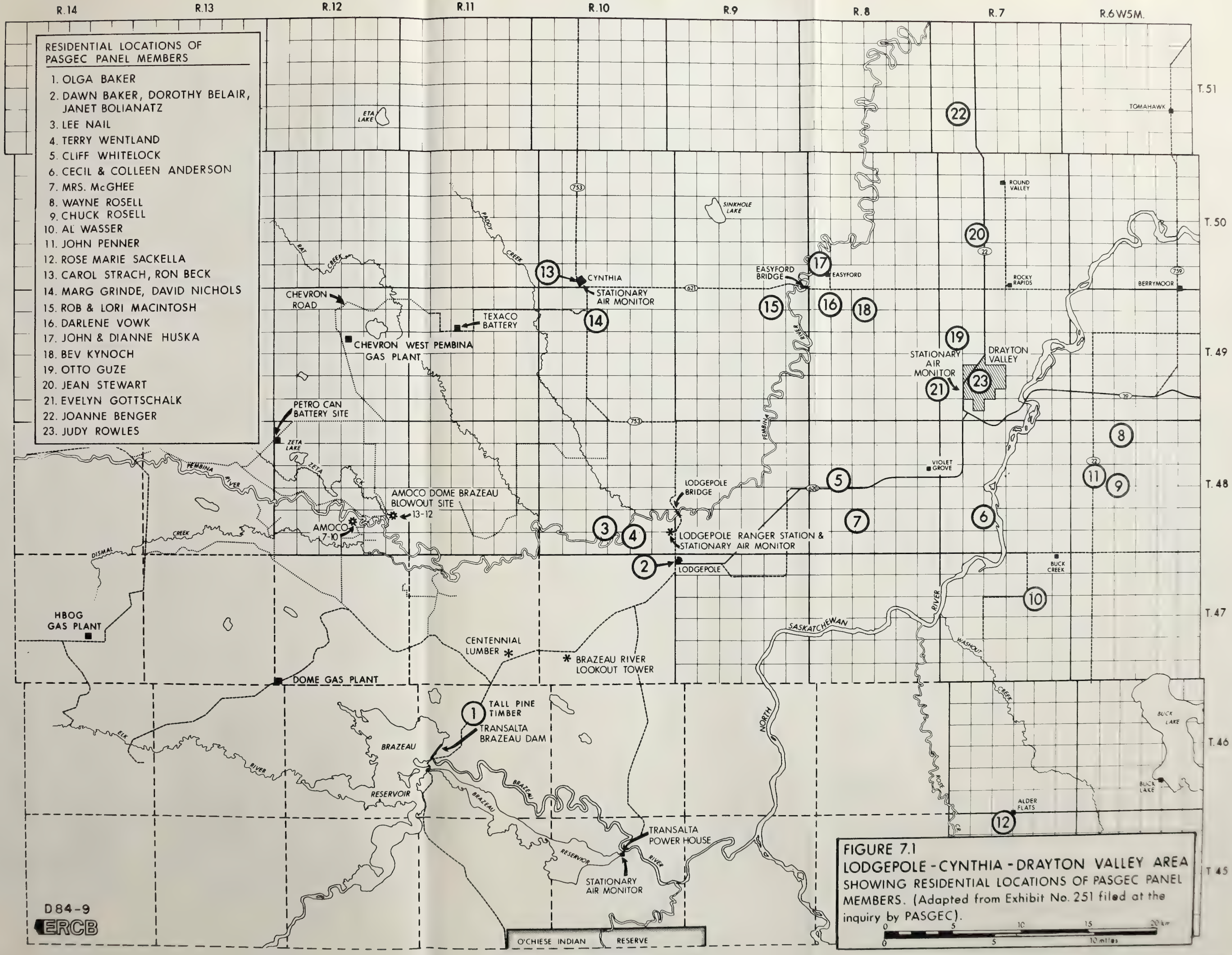


FIGURE 7.1
LODGEPOLE - CYNTHIA - DRAYTON VALLEY AREA SHOWING RESIDENTIAL LOCATIONS OF PASGEC PANEL MEMBERS. (Adapted from Exhibit No. 251 filed at the inquiry by PASGEC).

years. This disparity in opinion about abortions may be partly due to a failure of communication and inadequate submission of specimens. Unfortunately, this very important question cannot be resolved one way or the other on the basis of information now available.

In another matter related to livestock, staff of the Alberta Environmental Centre attempted to determine the effects of the emissions on certain important enzymes of cattle. Blood samples were taken from cattle from ten herds in the affected area during the blowout and subsequent to the capping of the well, as well as from two control herds in the Vegreville area.

These studies showed that some statistically significant biochemical perturbations did occur in animals within the exposure area. In all cases, however, the changes appeared to be transient and reversible. The investigators advised that these results are highly experimental in nature and must be interpreted with considerable caution, particularly when assessing suspected clinical disease in the animals. At present, the importance of these results is not known.

7.2.5 Differential Diagnostic Possibilities of Human Illness

There are two alternative differential diagnostic possibilities, other than a physical illness due to the emissions, to explain the illnesses of the 30 residents who presented evidence. These are either an acute infectious disease process which occurred at the same time as the blowout, or a psychological illness provoked by the stress of the situation. There is considerable evidence against these possibilities. It would be unusual for an infectious process to start simultaneously among a population so widely separated. As well, there was an absence of certain systemic symptoms so characteristic of most epidemics. The symptoms generally abated when the residents left the area and recurred rapidly when they returned during the blowout period. There was no evidence that an epidemic-type infection was identified by physicians local to the Drayton Valley area during the period.

A mass psychological illness is unlikely for a number of reasons, including the fact that such episodes have not been reported among stable farm families consisting of mature adults and very small children. The physical symptoms among the area residents were made up in large part of complaints which can be best described as irritation of exposed mucous membranes. Similar signs were noted in animals and there was an acknowledged disappearance of wildlife, including birds and small mammals. Air monitoring revealed levels of H_2S as high as 15 ppm for very short periods at residences inthe Lodgepole region. Recordings varied up to a peak of 30 ppm on one occasion and beyond 30 ppm on four occasions away from residences. Section 7.4.2 gives further details respecting monitoring results in the region.

In contrast, during an epidemic illness said to be of psychological origin which occurred in adolescent school girls in the Middle East, environmental levels of H_2S were of the order of 0.05 ppm. In a telephone survey, conducted without controls, of residents in Edmonton, Drayton Valley, and the Lodgepole region, Jarvis has suggested that "social contagion" explained the symptoms of residents in all areas. With respect to Lodgepole area residents, his interpretation seems to be that the illness seen in animals was due to a distortion of reality in the eyes of the observers. He thus applied the term "social contagion" to the population at a time when medical and environmental data was not available to him. It is noteworthy that the term was also used by Dr. Milby, who appeared as an expert witness on behalf of Amoco. He repeated the Jarvis explanation without a critical evaluation of the data on which it was based, including the lack of controls in that study.

7.2.6 Available Medical Literature

There was almost a total absence of information on the effects on humans of low level extended exposures to H_2S. Information is available describing the acute effects of high level accidental exposure in humans.

7.3 The Standards Adopted to Protect Human Health from Emissions from the Blowout

To protect the health of persons exposed to emissions from the well, it was necessary to determine the threshold concentration of the contaminants that could be safely accepted by exposed persons. At the time of the blowout, the concerns were related mainly to H_2S; however, during the course of the inquiry, reference was made to other possible contaminants. While the well was on fire, the H_2S was converted to SO_2 and its standards became applicable. The primary focus during the inquiry, however, was on H_2S emissions and the standards applied.

7.3.1 The H_2S Standards Applied During the Blowout and Their Basis

Several of the participants provided evidence respecting the H_2S standards applied during the blowout period. Amoco indicated that it had been advised by the ERCB that the following standards were in effect:

(a) if concentrations exceeded 5 ppm for 6 hours or 10 ppm for 1 hour
- suggest residents evacuate the area,

(b) if concentrations reached 15 ppm with an increasing trend
- advise all residents to leave the area, and

(c) if concentrations exceeded 20 ppm
- evacuation would be considered mandatory.

The evidence of AE and the ERCB staff generally confirmed Amoco's statements but there were some differences. For example, there appeared to be different interpretations about whether the mandatory evacuation limit of 20 ppm was in effect by 18 October or actually was adopted sometime later. Similarly, there was reference to an evacuation limit when concentrations exceeded 10 ppm for 8 hours. SS&CH stated that, at a meeting on 25 November, the PBOH agreed with the following action levels as presented by AE:

> "...healthy normal adults should be advised to evacuate an area where hydrogen sulphide levels exceeded 10 parts per million for eight hours. This level is the same as the eight-hour occupational exposure limit used in the Province of Alberta ..."
>
> "A concentration of 20 parts per million for any period was established as the level at which persons must evacuate."
>
> "... for persons believed to be more sensitive, ... the very young, the very old, and those with respiratory disorders. Evacuation was recommended for such persons when average levels exceed five parts per million for six hours or 10 parts per million for one hour in the presence of persistence or worsening of symptoms ...".

Reference also was made to the ERCB inquiry in 1978 which was held to consider the blowout of the 7-10 well in the same area. The report, Inquiry Report 78-8, indicates that the evacuation standard established for that occasion was that "... mass evacuation should not take place unless the H_2S readings exceeded 10 ppm for an extended period of time (five to six hours). Evacuation of sensitive individuals might be advisable at lower levels (5 ppm) ..." and that "Through consultation with medical experts from the Occupational Health and Safety Division, Alberta Labour, it was decided that persistent levels of 3 to 5 ppm hydrogen sulphide should require evacuation of residents very sensitive to hydrogen sulphide. At levels of 15 ppm persisting for longer than 15 minutes, all individuals should be evacuated."

The Panel concludes, on the basis of the somewhat confusing evidence, that the following evacuation criteria were in effect for most of the blowout period:

(a) suggest residents consider evacuation if concentrations become 5 ppm for 6 hours or 10 ppm for 1 hour,

(b) advise residents to evacuate if concentrations become 10 ppm for 8 hours,

(c) urge evacuation at 15 ppm, and

(d) require evacuation at 20 ppm.

The evidence suggests to the Panel that while reference was made to special standards for more sensitive people, that need was not specifically recognized in the standards except perhaps for the case of 5 ppm for 6 hours. In addition, there was no effort made to implement measures to determine who in the population was sensitive, and measures to protect these people, with the exception that Amoco was prepared to cover costs of relocation for persons who complained and wanted to leave the area.

At its meeting in January 1983, the PBOH decided to issue a booklet to inform residents of health information on H_2S which could be used for any future incident. The booklet was made public as an exhibit at the inquiry in January 1984. The following guidelines or standards for evacuation are included in the booklet:

> "If **average** H_2S levels exceed 5 ppm for 6 hours or 10 ppm for 1 hour or more and symptoms persist or become more severe, individuals should consider moving from the area until the levels are reduced.
>
> If **average** levels exceed 10 ppm for 8 hours or more, local conditions in the area will be assessed and you may be advised to leave the area until the levels are reduced.
>
> If environmental monitoring indicates that a level of 20 ppm or more will be reached and conditions indicate that a serious health hazard exists, mandatory evacuation will be carried out under the direction of your local municipality.
>
> Sensitive individuals such as children, the elderly or those with pre-existing disease conditions (asthma, emphysema, etc.) should consider leaving the area if symptoms persist. Medical advice should be obtained if possible."

The rationale for the exposure limits adopted by the PBOH was described by reference to the occupational exposure limit of 10 ppm for 8 hours. The limit was described as being "... consistent with many such exposure levels in other parts of the world ...". Relating the exposure to health effects, Dr. Orford testified that "Below 140 parts per million, irritant effects are not generally fatal but may lead to irreversible tissue damage. At 20 parts per million or above, conjunctivitis, which is eye inflamation, occurs in many people and in some cases, could be irreversible if exposure continues over a long period of time. At 10 parts per million or less, effects are short-term and reversible if they occur at all. This is the reason why most jurisdictions have adopted 10 parts per million as the eight-hour occupational exposure limit".

PASGEC was very critical about the evacuation standards contending that they were inappropriate. It was especially concerned about the more sensitive residents who could be at risk from the H_2S concentrations. Several of the witnesses referred to this matter and described how actual concentrations affected them or their family.

The evidence indicates a degree of confusion or uncertainty with respect to the evacuation limits that were in effect during the blowout period. The most common standard appears to have been 5 ppm for 6 hours or 10 ppm for 1 hour, which was used for suggesting evacuation. Advice to leave immediately was triggered at 15 ppm and mandatory evacuation would have taken place at 20 ppm. While reference was made to lower rates applying to more sensitive people, except for Amoco, there was no indication that these rates were applied during the blowout period.

The Panel believes that there was a deficiency in the standards during the event with respect to sensitive people. The current standards issued by the PBOH make reference to the more sensitive individuals but they do not provide any specific guidelines except to recommend evacuation "... if symptoms persist" and to obtain medical advice. The Panel believes that further consideration should be given to identifying appropriate action for sensitive individuals exposed to H_2S. The results of the monitoring data described in the following section may provide a basis for that reconsideration. The Panel recognizes that the problem is difficult but believes it should be addressed.

7.4 Monitoring H_2S Emissions from the Well

The emissions from the 13-12 well, while it was out of control and not on fire, posed a potentially serious threat to people living or working in the area. Only a few families resided in the immediate area and the nearest communities were some 20 km distant. Because of the potential dangers, it was imperative that an effective monitoring program for H_2S be implemented quickly. The following sections describe and comment on the monitoring program, the monitoring results, and the effectiveness of the program.

7.4.1 The Monitoring Plan

At midnight on 17 October 1982, the first AE mobile air monitor commenced monitoring in the Lodgepole area. Amoco had two monitors in the area which did spot checks during the night. The ERCB monitor arrived at noon on 18 October and before the end of the day four mobile air monitors were continuously monitoring in the area. A fifth unit, AE's mobile laboratory, was in the area on 23 October. Additionally, two stationary monitors were established at the nearby community of Lodgepole and at Drayton Valley which is some 45 km from the well. Later, stationary monitors were established in Cynthia and at the Brazeau Dam site on 23 and 28 October, respectively. The location of the stationary monitors and the area generally surveyed by the mobile monitors is shown in Figure 7.2.

The rationale for the monitoring program was to maintain a check on the H_2S concentrations in each of the population centres through the stationary monitors and to use the mobile monitors to check on concentrations in the rural areas, particularly near residences or occupied areas. The mobile monitors attempted to define the highest H_2S concentrations with the objective of being able to identify the most serious situations. The monitoring was conducted on a 24-hour basis and was co-ordinated by AE. Monitoring results from both the stationary and mobile units were used to identify the high concentration areas. Evidence submitted at the inquiry indicated that where high concentrations were identified, mobile monitors would converge on the area to ensure that monitoring was sufficient to identify any potential danger. The general plan was premised on either the evacuation of people where the monitoring indicated that the evacuation standards would be exceeded or the ignition of the well when evacuation was not practical, such as in Drayton Valley.

Participants at the inquiry identified several criticisms of the monitoring program. Probably the major complaint was the lack of information provided to residents about either the plan or the H_2S concentrations recorded by the monitors. For example, several local residents testified that they had called either the ERCB or Amoco to advise that concentrations appeared to be very high in the area and had requested that the situation be investigated. A monitoring unit was promised but the caller did not receive confirmation of either its arrival or the results. Consequently, many believed that the requests had not been checked. In contrast, the evidence provided by the monitoring representatives indicated that the calls were always responded to, but as long as the situation was not serious, monitoring personnel did not always consult with the local residents.

Other criticisms related to whether there were enough monitoring units to satisfactorily cover the entire area potentially affected and whether the recording instruments were adequate for the concentrations being encountered. With respect to the five mobile monitors, the evidence indicated that automatic recording devices were in four of the monitors with limits of 10, 10, 5, and 1 ppm H_2S, respectively. The other monitor was capable of monitoring up to 30 ppm but it did not have an automatic recording device. In three units, the automatic recording instruments were supplemented by Drager units which could be used to detect approximate concentrations up to 60 ppm, and two units had Dictaphone instruments which could read up to 100 ppm. The stationary units at Cynthia, Lodgepole, Drayton Valley, and Brazeau Dam had recording capacities of 3.27, 5, 5, and 1 ppm, respectively.

Participants questioned whether unmanned stationary units were adequate and some suggested Drager instruments and crush ampoules should have been provided to residents, especially in more remote areas and in the Pembina River Valley. The Panel believes the suggestion of supplying Drager instruments and possibly crush ampoules to residents in remote rural areas should be considered, along with instruction in their use, as part of an overall monitoring program.

In the Panel's view, the design of the monitoring program was generally appropriate. The Panel agrees with the decision to use a combination of stationary and mobile monitors with the latter roving the area to identify high concentrations and ensure the protection of isolated residents. The evidence on the monitoring results, which is discussed in section 7.4.2, indicates that the monitoring units engaged in the program were generally sufficient to effectively carry out the responsibilities, however, one or two additional units would have been advantageous to allow for possible emergencies and occasions when the monitoring units were inoperative. Additionally, it would have been preferable to employ units capable of measuring higher concentrations of H_2S but the Panel recognizes that such units were not readily available. Having regard for the fact that there was no preplanning for monitoring in the event of a blowout, the Panel believes that the plan was as complete and extensive as could be expected. The Panel agrees that such a general plan should be established and AE should co-ordinate it in any future event.

The major deficiency in the monitoring plan related to communications. With the advantage of hindsight, it is clear that special efforts should have been made to provide local residents with information about the monitoring plan as well as the detailed results of it, including specific readings. Additionally, the program would have been enhanced and may have resulted in better communication to the press and the public if a central dispatcher had been in charge of the program. By appropriate advance planning, particularly by AE and the ERCB, some of the problems encountered in the Lodgepole case could be avoided and a more credible system could be implemented for any future incidents.

7.4.2 Monitoring Results

7.4.2.1 H_2S Concentrations Over the Broad Area

Amoco presented the results of the mobile and stationary monitors by isopleths of average hourly concentrations for each day that the well was out of control and not ignited. It contended that these data provided a fair representation of the concentrations in the area. The data were subject to extensive examination at the inquiry and there was considerable controversy about their interpretation and validity. Some participants alleged that actual peak recordings during the Cynthia episode on 23 and 24 November, when concentrations in the Cynthia area were high and evacuation was being considered, were substantially higher than indicated by the average hourly data.

AE filed the operator's notes from its mobile monitoring units and half-hourly and hourly averages for the stationary monitors. Various attempts were made through examination to compare the AE data with the results presented by Amoco.

One of the interpretational problems related to the method of calculating average hourly concentrations when the readings for the mobile monitors were "off scale". Amoco indicated that under those circumstances, providing the concentration continued for more than 1 minute, the instrument's maximum reading was assumed to apply for the full hour. For its stationary units, AE averaged the readings over the hour and added a greater-than sign to the reading. Further details respecting the determination of hourly average concentrations are provided in Appendix 7.

The extreme variability of the mobile monitoring data also resulted in interpretational difficulties and questions about the data. Amoco contended that extreme variations in concentrations were to be expected because the plume was almost constantly moving due to atmospheric conditions and consequently there were extreme gradients between the outer edge of the plume and its centre. Some participants questioned whether the data were reliable and whether the monitoring plan was actually followed. Others suggested that the variability indicated the difficulties of attempting to construct isopleths on the basis of mobile monitoring data.

The Panel has reviewed the data filed in evidence. It does not believe that the hourly average contours calculated on the basis of mobile monitoring data are a valid representation of the actual concentrations. In its view, there is insufficient data to derive meaningful average hourly concentrations because the mobile monitors were virtually always on the move and the concentrations were obviously variable depending on the path of the plume. The mobile monitoring was designed to identify the location of the highest concentrations in areas where there were residents and no stationary monitors. It was not designed to provide a base for calculating hourly average concentrations over the area. A further complication was the fact that in the high concentration areas, the readings from the automatic recording devices for both stationary and mobile monitors were sometimes off scale and actual concentrations were determined by the Dictaphone and Drager units. The fact that the average hourly concentrations depicted in the figures presented by Amoco could not be used does not, in the Panel's view, detract from the effectiveness of the monitoring program itself. It simply means that there is insufficient data to determine average concentrations over the broad area.

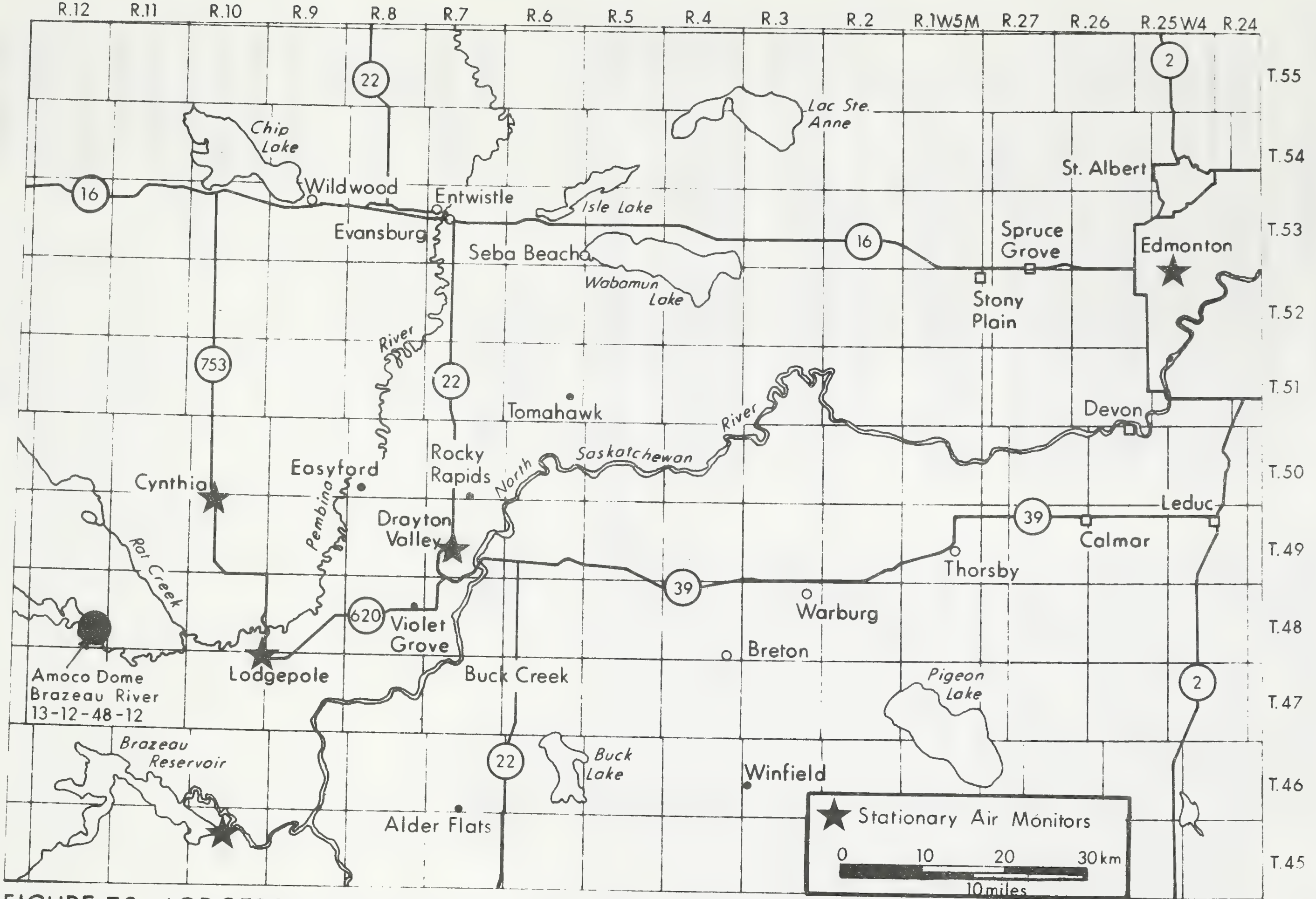


FIGURE 7.2 LODGEPOLE - EDMONTON AREA SHOWING LOCATION OF STATIONARY AIR MONITORS

7.4.2.2 H_2S Concentrations at Populated or Occupied Areas

The Panel appreciates that local residents were seriously concerned about the H_2S concentrations particularly having regard for the limited information they received and the potential risks involved. In view of the controversy regarding the interpretation of the monitoring data, the Panel has summarized the monitoring results at residences for both stationary and mobile units by geographical location where concentrations greater than 5 and 10 ppm were recorded. The 5-ppm cut-off was selected because it was

(a) the upper suggested limit of the evacuation range for sensitive people,

(b) substantially less than the standards applied to workers on site and less than the evacuation criteria applied during the incident, and

(c) the upper limit of one of the mobile monitors.

The 10-ppm level was selected in order to identify the most serious levels and to relate them to the general evacuation standards.

Figure 7.2 shows the general area affected by H_2S emissions from the well. Two of the communities, Cynthia and Lodgepole, are approximately 20 km from the well, Drayton Valley is some 45 km, and Edmonton approximately 130 km distant. The area nearest the well is sparsely populated with a few ranches and farms as well as lumber and oil and gas operations.

Figure 7.3 shows in greater detail the area nearest the well including the prohibited entry area prescribed by ERCB Order FH 82-1. Residences and industrial operations where readings greater than 5 ppm were obtained are identified. Most of these were located within a 20-km radius of the well. The H_2S concentrations at those locations were monitored by the mobile units particularly when the concentrations were relatively high. H_2S levels in the communities of Cynthia, Lodgepole, and Drayton Valley were recorded on stationary monitors which were supplemented by mobile units when the former were off scale.

Figure 7.3 also shows the number of hours that monitors reported concentrations greater than 5 and 10 ppm. A review of the monitoring records indicates that all of the concentrations greater than 10 ppm were within approximately a 20-km radius. There were locations outside that area that experienced H_2S concentrations in excess of 5 ppm but not at residences or populated centres except for two instances at the hamlet of Violet Grove.

Table 7.1 provides additional detail respecting the recordings at each of the locations identified in Figure 7.3. In each case, the maximum concentration reported during the hour is shown in the table.

TABLE 7.1 H_2S CONCENTRATIONS GREATER THAN 10 AND 5 PPM RECORDED AT RESIDENCES

Location	Number of Hours H_2S Conc $>$ 10 ppm	Number of Incidents	Number of Hours H_2S Conc $>$ 5 ppm and $\leq$ 10 ppm	Number of Incidents
Centennial Lumber	9	3	18	8
Lodgepole	3	3	20	8
Chevron Gas Plant	6	3	3	3
Cynthia	2	1	6	1
Sargent Residence	4	2	2	1
Petro-Can Battery	3	2	1	1
Tall Pine Timber	1	1	3	3
Emperingham Residence	1	1	1	1
Nail Residence	1	1	1	1
Violet Grove	0	0	2	2
Proudlove Residence	1	1	0	0
Negraiff Lumber	0	0	2	2
Fell Residence	0	0	1	1
Texaco Battery	0	0	1	1

Table 7.1 shows that people living and working at Centennial Lumber were exposed to the highest H_2S concentrations recorded. For some 18 hours during the 26 days that the blowout was not ignited, the H_2S concentrations were greater than 5 ppm and for 9 hours they were in excess of 10 ppm. On one occasion, the concentrations reached 15 ppm and the people were evacuated. The maximum concentration reported was 23 ppm but that occurred after evacuation of the residents. A PASGEC witness stated she had been advised that the level reached 35 ppm on that occasion.

Lodgepole had 23 hours of H_2S concentrations in excess of 5 ppm and 3 hours in excess of 10 ppm, while Cynthia had 8 hours greater than 5 ppm and 2 hours in excess of 10 ppm. The maximum concentrations in each community were 14.5 and 14.0 ppm, respectively.

With respect to Cynthia, the Panel decided to provide details of the monitoring results for 23 and 24 November because of the controversy respecting the need for evacuation during that incident. Figure 7.4 shows the hourly concentrations over the episode on 23 and 24 November. In compiling Figure 7.4, the Panel has shown as an hourly reading the hourly averages presented by Amoco until the stationary monitor went off scale at 16:00. After that, the readings were obtained by mobile monitors and some are the maximum readings recorded during the hour, regardless of the duration, and others are hourly averages. Unfortunately, limited data is available for the hours 03:00 to 16:00 on 24 November because the stationary monitor was inoperative and the mobile monitors were called away at 03:00 to monitor in the area northwest of Lodgepole which resulted in the voluntary evacuation of the Sargent family at 06:05.

The Cynthia data shows that the hourly concentrations reached a peak of 14 ppm between 17:00 and 18:00 on 23 November and subsequently declined to less than 4 ppm by 03:00 and to 1 ppm at 06:00 on 24 November. Up to 03:00 on 24 November, the stationary monitor was supplemented by the three mobile monitors. The Panel is satisfied that the data shown on Figure 7.4 are reliable because the AE mobile monitor with an instrument range of 30 ppm, and the Amoco mobile unit, with a range of 10 ppm, were at or near Cynthia from 12:45 to 19:45 on 23 November and 16:00 on 23 November to 03:00 on 24 November, respectively.

Table 7.2 summarizes the data from the stationary monitors located in Cynthia, Lodgepole, Drayton Valley, Edmonton, and Calgary. For Cynthia and Lodgepole, the two communities located nearest the well, the H_2S concentrations exceeded 5 ppm for 8 and 23 hours, respectively, and were in excess of 1 ppm for about 5 and 13 per cent of the total monitored hours, respectively. Concentrations less than 0.1 ppm were recorded for 80 and 70 per cent of the time, respectively. For Drayton Valley, the concentrations did not exceed 5 ppm, exceeded 1 ppm about 4 per cent and were less than 0.1 ppm about 80 per cent of the time. In Edmonton, the maximum concentration was 0.52 ppm, and the maximum hourly average was 0.47 ppm and for about 93 per cent of the time was less than 0.1 ppm. For Calgary, the maximum concentration was 0.328 ppm,

TABLE 7.2 H_2S CONCENTRATIONS RECORDED IN POPULATED CENTRES BY STATIONARY MONITORS

H_2S Conc (ppm)	Cynthia		Lodgepole		Drayton Valley		Edmonton(1)		Calgary(1)	
	Hours	%	Hours	%	Hours	%	Hours	%	Hours	%
> 5	8(2)	1.5	23(2)	3.7	0	0	0	0	0	0
3 to 5	6(2)	1.2	12	1.9	4	0.7	0	0	0	0
1 to 3	10	1.9	47	7.6	18	3.1	0	0	0	0
0.5 to 1	19	3.7	24	3.9	20	3.4	0	0	0	0
0.1 to 0.5	67	13.0	84	13.5	74	12.6	37	6.87	9	2.9
< 0.1	407	78.7	430	69.4	470	80.2	497	93.1	289	97.2
Total	517	100	619	100	586	100	533	100	297	100

(1) The statistics presented for Calgary and Edmonton are averages of the readings recorded at the two stationary air monitors in each city.

(2) These numbers include readings from mobile monitors where the stationary capacity was exceeded.

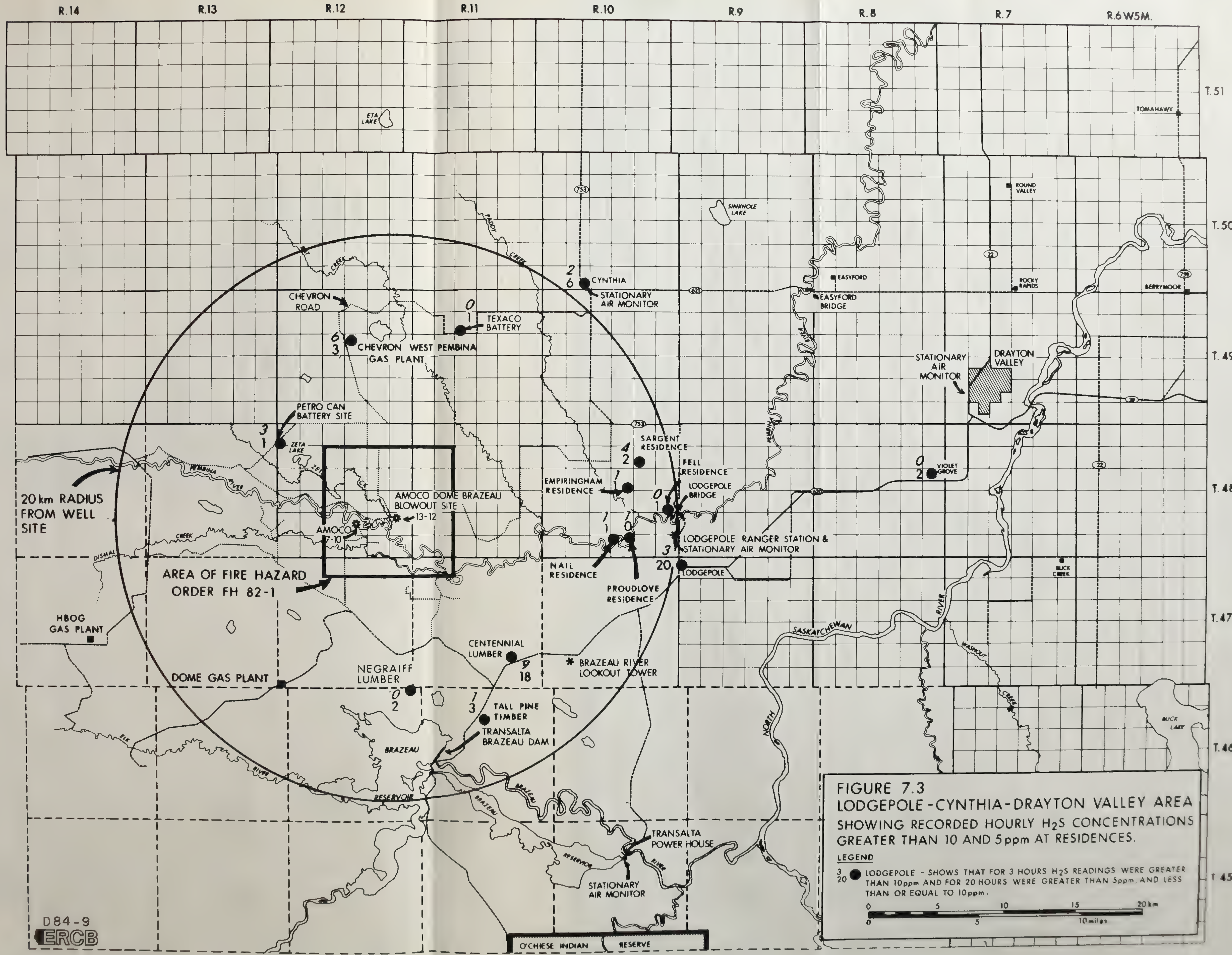


FIGURE 7.3
LODGEPOLE - CYNTHIA - DRAYTON VALLEY AREA
SHOWING RECORDED HOURLY H_2S CONCENTRATIONS GREATER THAN 10 AND 5 ppm AT RESIDENCES.

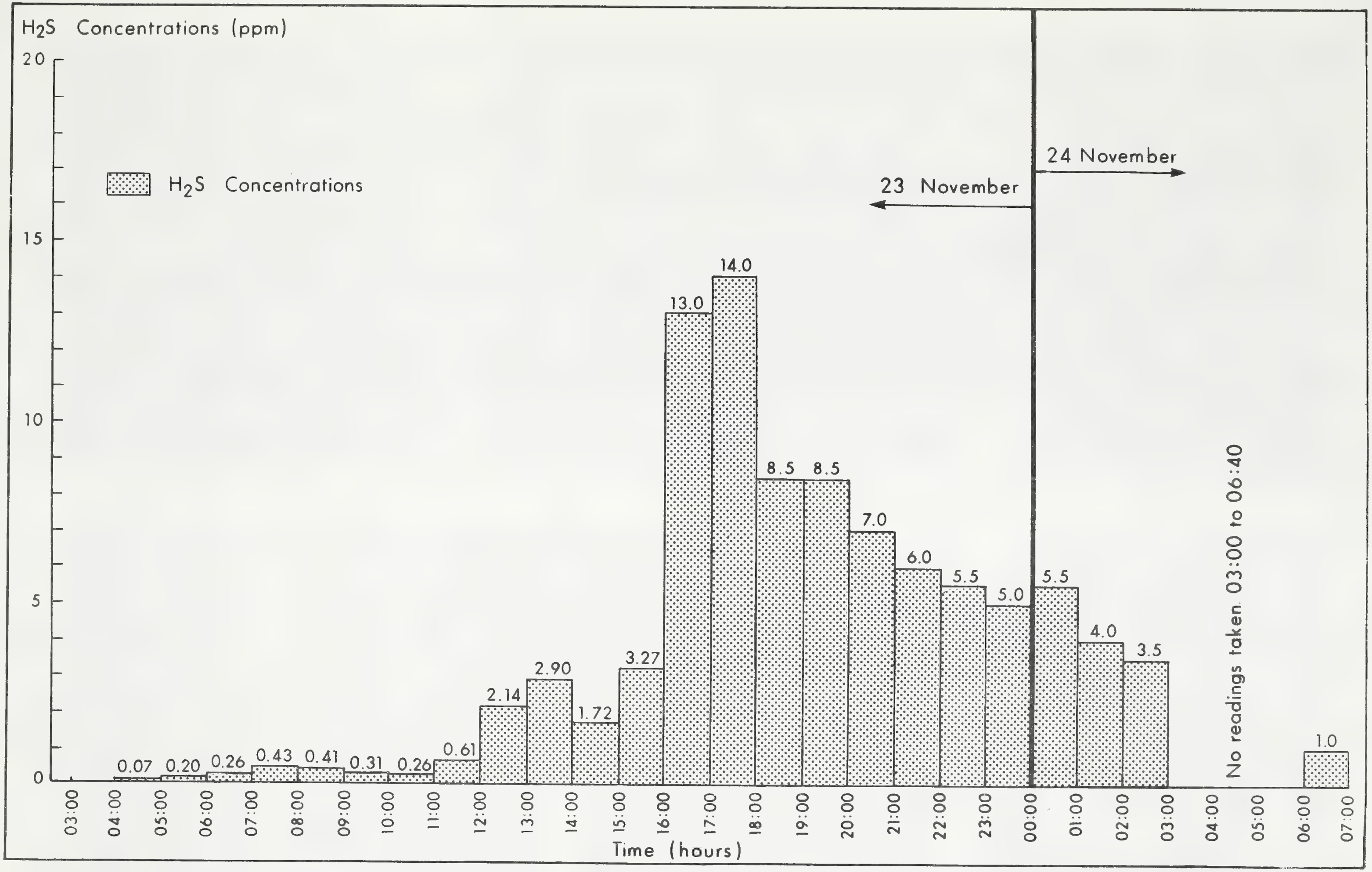


FIGURE 7.4 HOURLY MAXIMUM H_2S CONCENTRATIONS IN CYNTHIA. 23-24 November 1982.

and the maximum hourly average was 0.33 ppm and was less than 0.1 ppm for about 97 per cent of the time. A more detailed review of the Calgary and Edmonton data indicates that about 12 per cent and 22 per cent, respectively, of the total monitored hours were in excess of 0.01 ppm, which is the generally accepted odour threshold for H_2S for most people. Similar analysis is not possible for the three communities near the blowout because the monitoring equipment was not sufficiently sensitive, but based on Table 7.2, the Panel believes the percentages would have been significantly greater and probably in the order of 40 to 50 per cent. The Panel presents this data because it might have significance in considering appropriate standards and action for the more sensitive people.

7.4.3 Effectiveness of the Monitoring

In the Panel's view, the monitoring program allowed for rapid detection of serious H_2S concentrations and thereby permitted warning and protection of residents in the area. The location of stationary monitors in settled communities was sound and the use of mobile monitors for the scattered residents was practical. The major deficiencies related to communicating with the public the details of the monitoring plan and its results. Additionally, the lack of adequate back-up strength became apparent on 24 November when the Cynthia monitor became inoperative and the mobile monitors were required to cover an area of more serious concern. The Cynthia incident was further complicated by the limited recording range of the stationary monitor and the fact that it was not manned except for the first two weeks. With respect to the monitoring instruments, it would have been much more satisfactory if the stationary monitors had been continuously supervised, had the recording capacity of stationary and mobile monitors been not less than the mandatory evacuation standard, and each equipped with continuous recording devices.

7.5 Adequacy of Emergency Response Plan

Several participants contended that a site-specific emergency response plan is necessary in order to deal effectively with a blowout. Particular reference was made to the identification, location, and other details of persons who might be affected by a blowout. The Amoco response plan was a general plan rather than site-specific and engendered considerable discussion. The Panel agrees that a site-specific emergency response plan should be part of the requirement for a critical sour well and that concept has been included in the ERCB's Draft Interim Directive for critical sour wells. After reviewing the Amoco plan, the Panel can also see considerable merit in having available to all parties a general response plan that provides information that would help in responding to any blowout. The Panel recognizes that such a plan has been prepared and will be reviewed after this report has been issued. The plan is referred to further in section 9.5.

Reference was made at the inquiry to the use of the 100-ppm H_2S isopleth in the ERCB's Interim Directive ID-OG-76-2 as the basis for emergency sour gas procedures. PASGEC contended that it would be much more appropriate to use a 15-ppm isopleth since that represented the evacuation criteria.

It appears to the Panel that PASGEC's recommendation inherently assumes that:

(a) the purpose of the emergency response plan is to provide specific plans for every case where a person might need to leave an area because of a sour gas release, and

(b) the H_2S concentrations predicted by the isopleth model are reasonably representative of those that would prevail during a sour gas release.

The Panel questions whether the first assumption is practical or in the best interest of the public. A sour gas release can result in a variety of situations. If the release is near a major population centre, then immediate ignition would likely be the required action because evacuation would not be practical. If the release is near a less populated area, then the evacuation of those people in immediate danger would probably be required. Persons residing farther from the release, while not in immediate danger, might need to be evacuated under certain special circumstances. An effective monitoring system is required in order to identify those special cases.

As the Panel sees it, the site-specific emergency response plan should spell out the immediate action that would be required in the event of an emergency. It would identify those residents in immediate danger from the release and specify the actions to be taken. The general emergency plan would address broader issues, such as implementing suitable monitoring programs, communication with the public, and advising residents that might require evacuation. The Panel recommends that the ERCB and Government departments give further consideration to these matters after obtaining the views of industry and the public.

The assumption that the isopleth model provides concentrations comparable to those that could be expected from a sour gas release can be tested by comparing actual and predicted H_2S concentrations during the 26 days the 13-12 well was not on fire. Figure 7.5 shows the 15-ppm isopleth. Because of the uncertainty respecting the actual flow rate from the well, and since current evidence suggests the flow was likely greater than 1.4×10^6 m^3 per day, the Panel has calculated the 15-ppm isopleth on the basis of flow rates of 1.4 x 10^6 m^3 per day and 2.1 x 10^6 m^3 per day. The shaded area shown in Figure 7.5, therefore, represents the probable bounds of the 15-ppm isopleth.

Good monitoring data is available with respect to the outer limit of the 15-ppm band. Drayton Valley, which is just beyond the outer circumference, did not have any concentrations greater than 5 ppm. Mobile monitoring recorded two occasions when the concentrations at Violet Grove were in excess of 5 ppm. The mobile monitoring did not record any other cases of concentrations greater than 5 ppm at residences located within the band. The stationary monitor at Drayton Valley recorded only 4 hours or 0.7 per cent of the total monitored hours when the concentrations were between 3 and 5 ppm. Cynthia and Lodgepole are located to the west of the 15-ppm isopleth band and would therefore be expected to have higher isopleth calculations. The Lodgepole monitor recorded 3 hours when the concentrations were greater than 10 ppm and 20 hours when they were greater than 5 ppm but less than 10 ppm. In the case of Cynthia, there were 2 hours when the concentrations exceeded 10 ppm and 6 hours when they were greater than 5 ppm but less than 10 ppm. On an overall basis, H_2S concentrations at Cynthia were greater than 5 ppm for 1.5 per cent of the recorded hours and 3.7 per cent in the case of Lodgepole. As indicated previously, all of the concentrations greater than 10 ppm recorded by mobile monitors at residences were within the 20-km radius of the well and to the west of the 15-ppm band.

On the basis of the foregoing comparison, the Panel concludes that the isopleth calculation results in predicted values that are about three times greater than those actually measured during the 26 days, even for those special instances when extreme meteorological conditions prevailed. The data suggests that for 95 per cent of the time or more, the difference between predicted and measured would be several times greater than the factor of 3.

Notwithstanding the foregoing comments, the Panel agrees that further consideration be given by the ERCB and other parties to the appropriateness of using the 100-ppm isopleth for determining the area that should be included in the site-specific emergency response plan.

7.6 Evacuation of Residents Due to H_2S Concentrations

Amoco's evidence at the hearing indicated that it was prepared to cover the cost of persons who wished to move out of the affected area. Some 28 persons plus 4 families changed domicile for varying periods under this arrangement. In addition to these voluntary transfers, the evidence indicated six instances during the period when residents evacuated because H_2S concentrations were increasing towards 15 ppm. These are summarized below:

29 October 1982 – Empiringham Residence
20 November 1982 – Centennial Lumber
17 and 20 November 1982 – Tall Pine Timber
21 and 24 November 1982 – Sargent Residence

A few of the oil industry operations were also evacuated because of concentrations reaching the evacuation limit.

Evacuation of Cynthia was under active consideration on 23 November. H_2S concentrations increased from about 2 ppm at 12:00 to 13 ppm by 16:00 (Figure 7.4). By 17:00, the concentration had increased to 14 ppm and between 17:30 and 17:50, residents were notified of the high readings and advised that evacuation might be necessary. The concentrations then began to decline and by 18:00 were 8.5 ppm. The inquiry record indicates that notification of residents was discontinued at 18:15. By 24:00, the concentration had declined to 5 ppm.

The Panel has compared the monitoring results with the H_2S evacuation standards outlined in section 7.3.1 to determine whether those standards were actually applied. It will be recalled that the following standards were used:

(a) in excess of 5 ppm for 6 hours or 10 ppm for 1 hour – suggest residents consider leaving the area,

(b) in excess of 10 ppm for 8 hours – advise residents to leave,

(c) in excess of 15 ppm – urge residents to leave, and

(d) at 20 ppm – require evacuation.

For the areas protected by the mobile monitors, the only really effective standards were those for urging or requiring that evacuation take place when H_2S concentrations were found to be 15 ppm and 20 ppm, respectively, since the other standards required continuous monitoring data. The Panel's review of the monitoring data indicates only a few instances of 15 ppm concentrations at residences or populated areas, and in each case, the records show that the people left the area upon being advised to do so.

With respect to the three communities where stationary monitors were installed and supplemented as necessary by mobile monitors, each of the evacuation criteria could be applied. There were no incidents at Lodgepole or Drayton Valley where H_2S concentrations exceeded 5 ppm for 6 hours, 10 ppm for 8 hours, or 15 ppm for any period of time. With respect to Cynthia, concentrations exceeded 5 ppm for 7 hours but, as indicated in Figure 7.3, the peak level of 14 ppm occurred during the second hour of readings greater than 5 ppm and thereafter declined to 5.5 ppm by the seventh hour. Subsequently, the concentrations declined to less than 5 ppm. There were 2 hours when the concentration exceeded 10 ppm and the maximum level did not rise to 15 ppm. The evidence shows that Cynthia

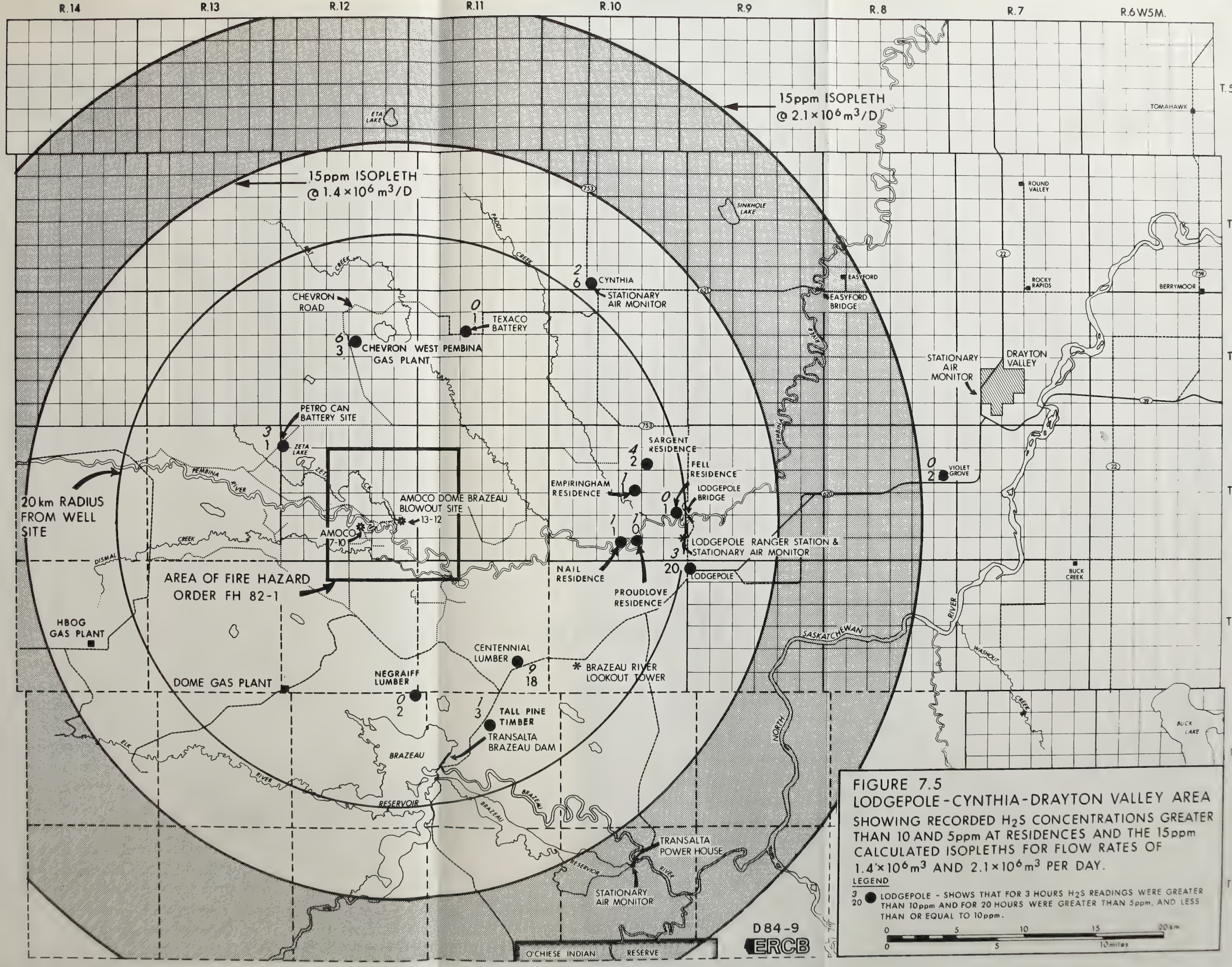


FIGURE 7.5
LODGEPOLE - CYNTHIA - DRAYTON VALLEY AREA
SHOWING RECORDED H_2S CONCENTRATIONS GREATER THAN 10 AND 5ppm AT RESIDENCES AND THE 15ppm CALCULATED ISOPLETHS FOR FLOW RATES OF $1.4 \times 10^6 m^3$ AND $2.1 \times 10^6 m^3$ PER DAY.

LEGEND

3/20 ● LODGEPOLE - SHOWS THAT FOR 3 HOURS H_2S READINGS WERE GREATER THAN 10ppm AND FOR 20 HOURS WERE GREATER THAN 5ppm, AND LESS THAN OR EQUAL TO 10ppm.

residents were advised of the possible need to evacuate although some of them may have been missed. When concentrations decreased, the program was cancelled, but it appears that this was also not fully communicated.

The Panel is satisfied that the evacuation standards were applied in Cynthia on 23 November but believes that communication was not adequate under those trying circumstances. The Panel believes that if Cynthia residents had been advised of evacuation procedures in the early stages of the blowout to prepare them for that eventuality, then some of the concerns and negative reactions would have been avoided. Additionally, if the complete information necessary to inform all residents had been compiled in advance, then the notification of residents of any necessary evacuation could have been carried out more effectively. A similar situation could have occurred at Lodgepole. The Panel believes that the emergency response plan should include provisions for informing residents of evacuation possibilities and procedures.

7.7 SO_2 and Other Emissions

While the focus of discussion at the inquiry related to H_2S emissions, reference was also made to SO_2 emissions, as well as to other emissions, during the time the well was on fire. Evidence indicated that the evacuation limits for SO_2 were 0.3 ppm for 24 hours and 1.0 ppm for 3 hours.

The Panel has compared the SO_2 monitoring data with the evacuation limits. With respect to the three communities in which stationary monitors were installed, the peak hourly concentration of 0.075 ppm occurred on 4 December at Drayton Valley. About 98 per cent of the time, the readings at the stationary monitors were less than 0.01 ppm. The maximum peak reading on the mobile monitors was 0.275 ppm which occurred on Highway 16 between the Devon overpass and Edson on 4 November. These results indicate that the SO_2 concentrations that occurred during the blowout were substantially less than the evacuation limits.

With respect to emissions of other components from the blowout well the Panel is not able to make any assessment because there is no data available. It understands that the ERCB has obtained samples of the well effluent and is having them analysed. Those results may provide useful information and should be made public. In addition, AE recommended that the ERCB determine the gaseous composition of various oil and gas fields in Alberta and the Panel agrees with the recommendation.

7.8 Summary of Panel's Views

Many individuals living in the Lodgepole region suffered from headache, respiratory, and gastrointestinal symptoms during the blowout. These people were exposed to H_2S during this time and it is probable that their symptoms were caused by this exposure.

Domestic animals in the Lodgepole region were similarly described as having watering of the eyes and coughing during the same period. The signs were probably caused by the same H_2S exposure.

Complaints about an unpleasant odour were received from a large number of people in Edmonton and areas remote from Lodgepole. Although H_2S in the Edmonton area did not exceed 0.5 ppm, this level substantially exceeds the odour threshold of the gas.

The condition of patients with chronic respiratory disease in Edmonton and areas remote from the blowout site who were exposed to low concentrations of pollutants may have been temporarily aggravated, but insufficient data was available to evaluate this possibility.

Government departments established and applied a set of H_2S exposure limits that were designed to protect human health. If concentrations exceeded those limits, then residents would be advised, requested, or ordered to leave the area. The most commonly applied exposure limit was 15 ppm. Special limits were established for people more susceptible to H_2S but, in fact, they were not applied.

Under the direction of AE, H_2S concentrations downwind from the well were monitored by a combination of mobile and stationary monitors to ensure that if concentrations exceeded the exposure limits, the residents would be advised and would vacate the area. On six occasions, H_2S concentrations near residences were in excess of 15 ppm and residents temporarily left the area.

During the 26 days that the well was not on fire, H_2S concentrations at or near residences exceeded 10 ppm for about 31 hours and 5 ppm for 61 hours (see Table 7.1). The stationary monitors located at Lodgepole, Cynthia, and Drayton Valley recorded concentrations less than 1 ppm for 87, 95, and 96 per cent, respectively, of the total hours monitored. In Edmonton, the maximum concentration recorded was 0.5 ppm, and the overall concentrations were about one-tenth of those for the three communities near the well.

In the Panel's view, it is paradoxical that the exposure limits were not exceeded, except in a few instances for susceptible persons, yet the anecdotal evidence indicates that the emissions probably caused temporary health effects. In view of this evidence, the Panel believes that the PBOH should give further consideration to appropriate exposure limits. The need for reconsideration is even greater for those persons who may be susceptible to H_2S.

While the monitoring was effective, the communication of the plan and its results to the local people was quite inadequate. Residents were not advised about the program, and were not always able to obtain answers to their inquiries about monitoring results.

While the well was on fire, the H_2S was converted to SO_2. Because of the intense fire, the emission plume had substantial rise, and its dispersion was effective. SO_2 concentrations were substantially below the related ambient air quality standards and health problems were not evident.

7.9 Recommendations

The Panel recommends that:

1 The PBOH reconsider its H_2S exposure limits in light of the Lodgepole evidence and in particular for "sensitive individuals".

2 Information be obtained by the PBOH on the biological effects of extended intermittent and continuous exposure to moderate and low level concentrations of H_2S, such as were experienced by residents and animals during the Lodgepole blowout. This could be obtained by modern research techniques.

3 AE, the ERCB, and representatives from industry and the public develop a comprehensive centrally dispatched monitoring plan that could be implemented immediately.

4 AE and the ERCB arrange for a comparison and analysis of actual H_2S concentrations obtained by monitors and the predicted concentrations from dispersion modelling with the objective of improving the latter capability.

5 Further consideration be given by the PBOH and other medical bodies to determine whether useful information could be obtained from a review of actual medical experience during the blowout, and to consider whether better measures can be implemented to determine the effects of emissions from other blowouts which may occur in the future.

6 Methods of providing remote rural residents with Drager units and possibly crush ampoules, and training in their use, be addressed in site-specific emergency response plans.

7 The ERCB should attempt to identify all of the gaseous contaminants, in addition to H_2S and SO_2, which could be produced by a sour gas well, since other components could also have biological significance. This type of physical chemical analysis could be carried out on material safely obtained from an existing well or wells.

8

Workers clearing Pembina River ice to assess potential damage.

Photo credit: W. Wylie, ERCB

8 IMPACT ON THE ENVIRONMENT AND ON PERSONAL PROPERTY

8.1 Introduction

During and following the blowout, Amoco engaged a wide variety of environment specialists to assist in addressing the suite of environmental problems including:

(a) air-shed evaluation (section 7 reports separately on the local area monitoring aspect),

(b) soils, vegetation, and reforestation,

(c) wildlife evaluation, and

(d) aquatic evaluation.

Others, including AE, Alberta Forest Service (AFS), and Alberta Fish and Wildlife (AFW), also pursued companion activities to address certain aspects of those environmental issues. As well, the Public Advisory Committee to the Environment Council of Alberta (PAC) retained consultants to perform a detailed post-event evaluation to determine potential adverse biophysical effects resulting from the well emissions.

The Panel finds it convenient to address the environmental impacts under two main headings:

(a) **On-Site and Immediate Area**

This area, depicted in Figures 8.1 and 8.2 and up to about 6 km from the well, was very heavily impacted by condensate precipitation and subsequent fires.

(b) **Local Regional Area**

This area, depicted in Figure 8.3 is a region some 60 to 70 km beyond the immediate site, believed by PAC to be exposed to measurable sulphur loading from the well emissions.

8.2 Background Information

The 13-12 well blowout resulted in extremely large emissions of gaseous and liquid hydrocarbons and other compounds, extending from 17 October to 23 December 1982. During the period 17 October to 1 November, the raw gas was emitting through a restricted opening of crimped 114.3-mm (4.5-inch) drill pipe still hanging in the rig BOPs. The emission rates during this period were variously estimated to be in the range of 0.4 to 0.8 x 10^6 m^3 per day. After the rig caught fire and burned down, and all of the debris was removed, flow was emitting from a 244.5-mm (9.625-inch) casing with no surface obstructions. Most of the post-event evaluations and evidence provided at the inquiry were predicated on estimated flow rates of about 1.1 to 1.4 x 10^6 m^3 per day from 1 November until the well was capped.

Following is a brief table showing estimates of the rates and nature of well emissions during the key time intervals:

DATES	RAW GAS RATE (10^6 m^3/d)	CONDENSATE FALL-OUT (m^3)	SULPHUR RATE (t/d)	EMISSIONS
Stage 1 — Raw Gas Plume				
17 Oct – 1 Nov (15 days)	0.4 to 0.8	300 – 600/d	150 to 300 primarily H_2S	Most of the raw gas, including sulphurous (H_2S) gas, dispersed over a broad area. Deposition was greatest in the local area. Local regional effects occur.
		4 500 to 9 000 cumulative condensate on site		Most condensate settled near the site on forests and frozen ground. Subsequent fire burned most of this condensate.

DATES	RAW GAS RATE (10^6 m^3/d)	CONDENSATE FALL-OUT (m^3)	SULPHUR RATE (t/d)	EMISSIONS
Stage 2 — Well on Fire				
1 Nov – 14 Nov (13 days)	1.4	1 100/d	450 (900 of SO_2)	Well on fire. Gas and condensate incinerating at point of emissions. Main products are H_2O, CO_2, and SO_2. Major impact potential from SO_2.
		14 000 cumulative incinerated		On-site soils thawed and dried out from intense heat. Forest burned and additional clearing created dry barren soil area around well.
Stage 3 — Raw Gas Plume				
14-25 Nov (11 days)	1.4	1 100/d	450 primarily as H_2S	Similar plume impacts as in Stage 1, but higher emission rates resulted in greater local regional impacts.
		12 000 cumulative on site		Condensate precipitated onto dry, exposed soils on site and a portion seeped through soil into substrata. Groundwater and nearby snow and ice-covered surfaces of Zeta Creek and Pembina River received some condensate deposition.
Stage 4 — Well on Fire				
25 Nov – 23 Dec (28 days)	1.4	1 100/d	450 (900 of SO_2)	Condensate and gas incinerated at emission point.
		31 000 cumulative all incinerated		Effects similar to Stage 2 except for atmospheric variances.

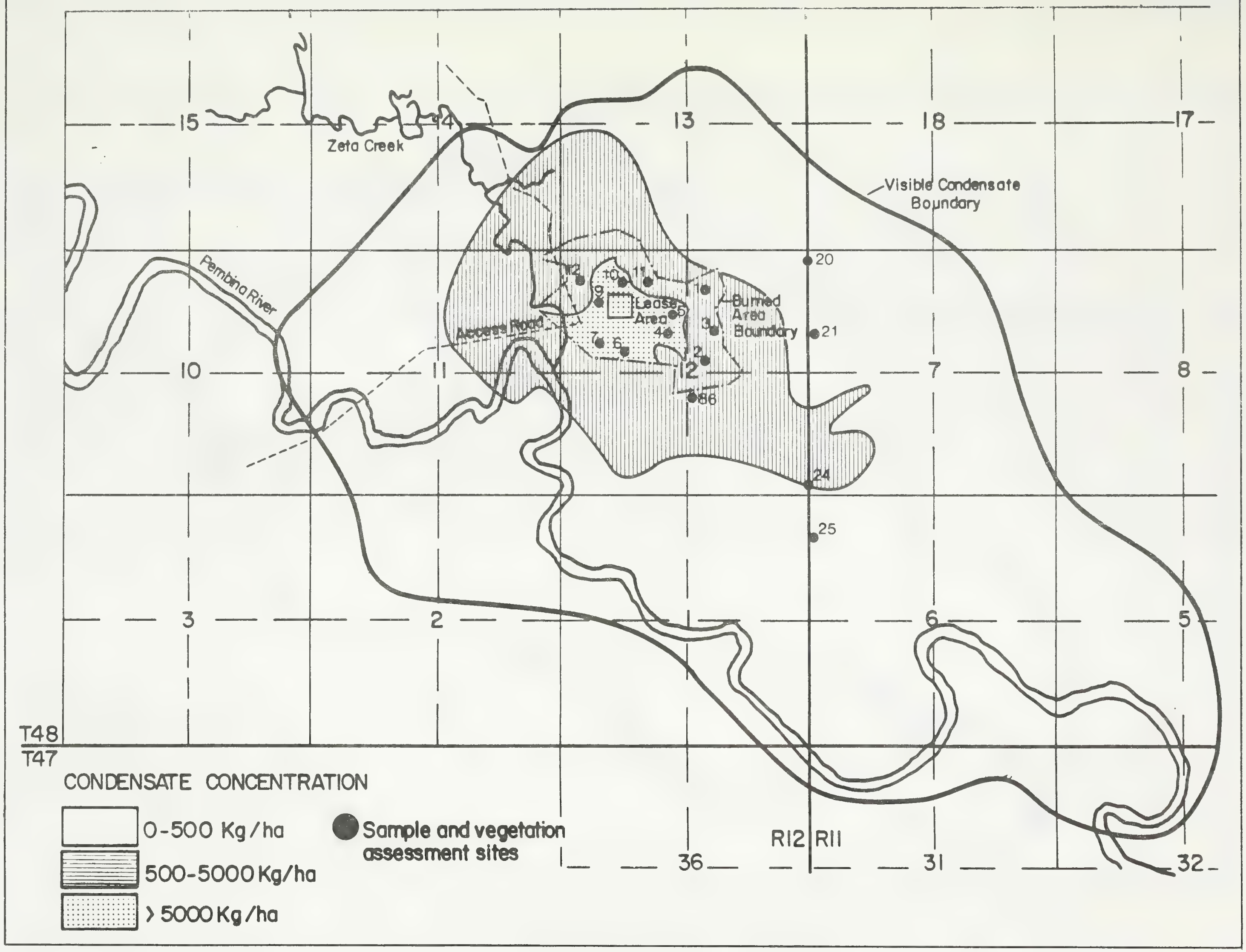


FIGURE 8.1 CONDENSATE DISTRIBUTION AROUND THE 13-12 WELL.
Reproduced from Exhibit No.173.

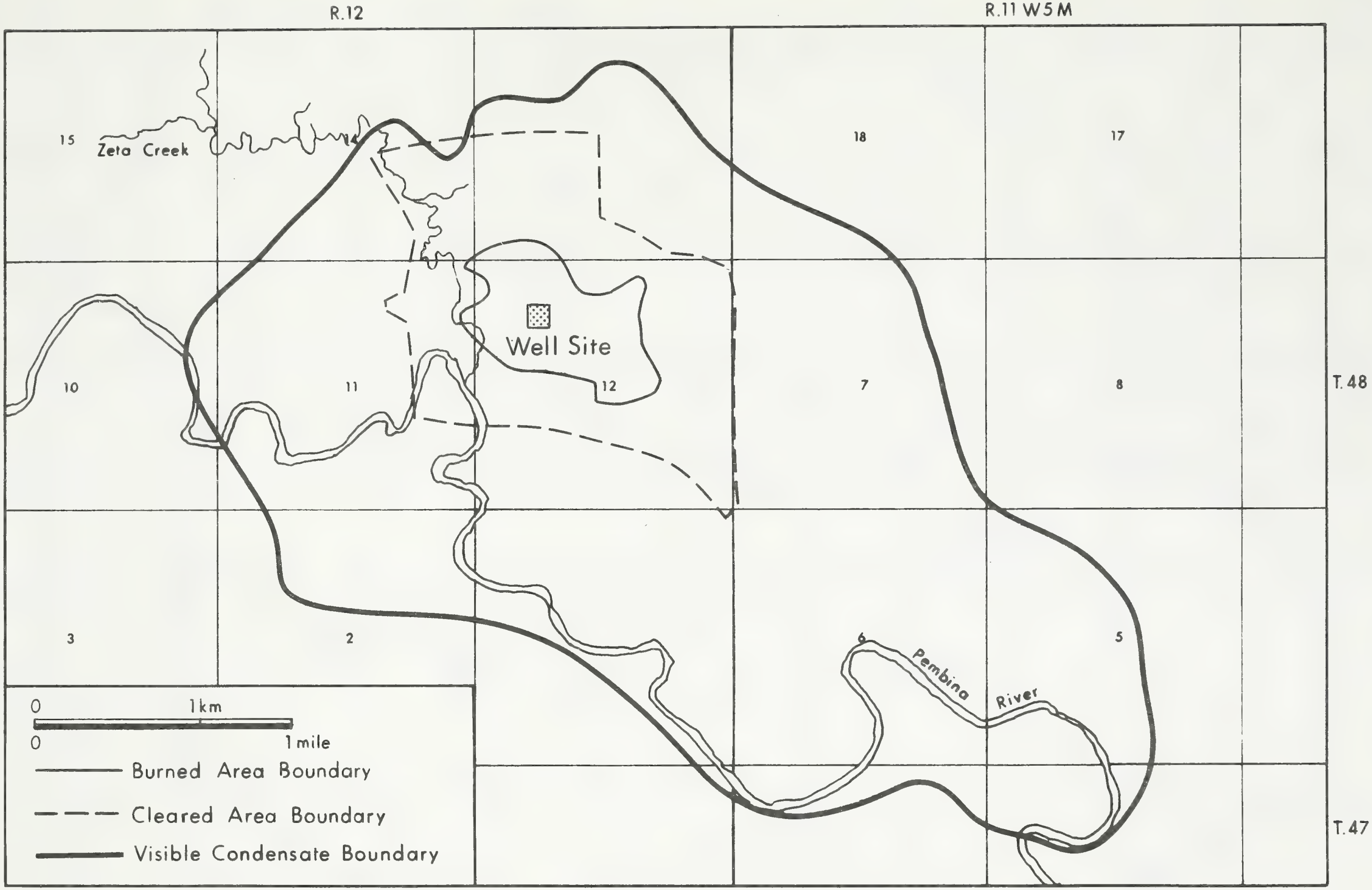


FIGURE 8.2 FOREST CLEARING AREA AROUND THE 13-12 WELL.

Based upon " Effects of the 1982 Amoco-Dome Brazeau River 13-12-48-12-W5 Well on the Environment (Soil and Reclamation Component)" Volumes 1 and 3 filed as Exhibits No. 95 and 95.2, respectively.

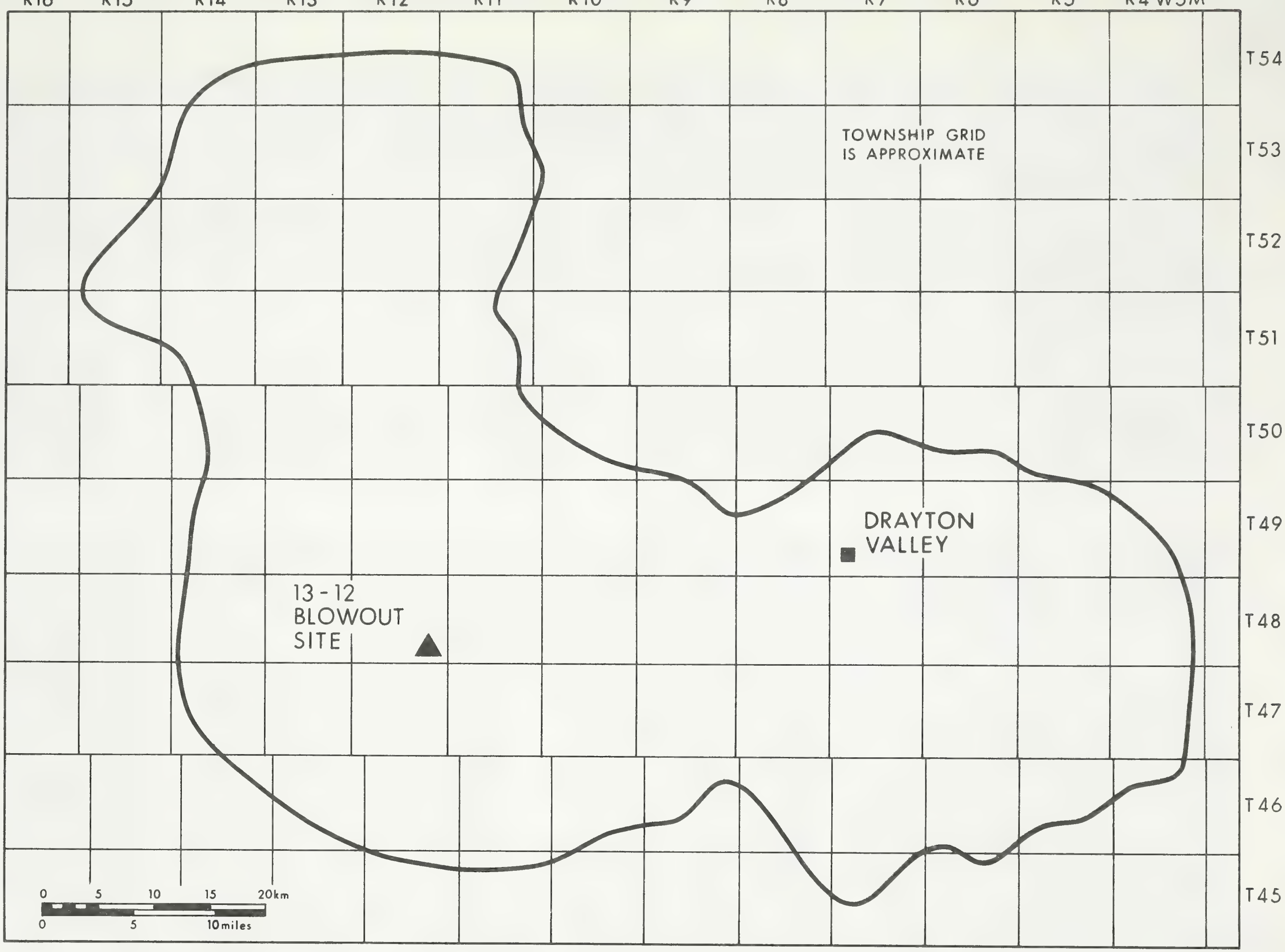


FIGURE 8.3 BOUNDARY OF MEASURABLE SULPHUR DEPOSITION AROUND THE 13-12 WELL. (AS SHOWN IN EXHIBIT NO.92).

8.3 On-Site and Immediate Area Impact

By visual observation and field sampling, after the blowout was controlled, Amoco was able to describe the area shown on Figures 8.1 (condensate) and 8.2 (fire and forest removal) as areas of intensive environmental impact. In these areas, though toxic gaseous emissions obviously would have had some effects on forest vegetation and wildlife, the most obvious and dramatic impact was that from "condensate rain and mist" and from the fires that engulfed the well-site area.

8.3.1 Air

When the well was not on fire, in order to ensure safe working conditions at and near the site, Amoco safety personnel continually monitored to determine H_2S concentrations at the well site, the staging areas (2 to 3 km away), and access routes. During this period, there were 5 half days and 6 full days when Amoco decided to halt work on the well because H_2S levels were too high. Also, a few days after the blowout, Amoco closed its base camp some 5 km north of the well because of the risk to personnel of H_2S exposure during night-time atmospheric inversions. The combination of on-site and off-site monitoring and plume observations thereafter satisfied Amoco that atmospheric dispersion was reducing plume concentrations to well below worker-tolerance levels in most areas beyond 1.5 to 3 km of the well.

After the first fire, Amoco reported finding three dead moose about 500 m from the well and a dead raven near the site. It can be inferred from the Amoco and Nabors evidence that on some days quite high concentrations of sour gas could develop and linger for some time near the well-site area.

It is evident that when the well was not on fire, relatively high concentrations of H_2S occurred near the well site on those days and nights when atmospheric conditions resulted in inefficient plume dispersion. Of the total 26 days when the well was not on fire, some of the daytime periods showed measured concentrations greater than 50 ppm near the well. It is probable that night-time conditions would have shown even higher H_2S concentrations owing to night-time inversions. These conditions would have had an adverse effect on all air-breathing beings in the near vicinity of the well.

8.3.2 Soils, Vegetation, and Groundwater

8.3.2.1 Soils

Amoco identified the visible condensate deposition boundary as shown in Figure 8.1. Amoco testified that 30 000 to 32 000 m^3 of condensate fell within this area during the times the well was not on fire. However, evaporation (estimated at 40 per cent of the condensate liquid), subsequent incineration from the lease-area fires, and migration of condensate into the substrata reduced the available condensate on the surface to a relatively small amount. Surveys by Amoco in the summer of 1983 showed, except for an area of some 39 ha around the well, as shown in Figure 8.4, that only the upper 7.5 centimetres (cm) of soil contained adsorbed condensate. In these areas, the concentrations were low ($<$ 500 kg/ha) and were expected to biodegrade without problems. However, as shown in Figure 8.4, concentrations of 25 000 to 75 000 kg/ha, equivalent to a high impact oil spill, exist in 10 ha of low-lying grounds near the well and 10 000 to 25 000 kg/ha exist on another 29 ha. Amoco has concluded that the combined 39 ha, medium to heavy condensate-saturated soils areas, will require stimulation of natural biodegradation in order to achieve full rehabilitation over a period of years.

Referring to the table, the Panel concludes that the condensate emitted during Stage 1 precipitated near the well and the subsequent fire probably burned up most of it. Additionally, the Panel believes that the 12 000 m^3 of condensate that precipitated during Stage 3 (14 to 25 November) would have constituted the main source for long-term contamination of soils and groundwater.

Respecting soils only, the Panel accepts Amoco's view that although biodegradation will gradually remove the condensate, considerable reclamation effort will be required over a number of years to fully rehabilitate the more heavily affected areas.

8.3.2.2 Vegetation

Amoco filed evidence showing that in the immediate well-site area, the impact of the condensate emissions on vegetation was both major and dramatic. During the periods when the well was on fire, both forest and ground vegetation were burned or removed from areas near the well as shown in Figure 8.2. To determine longer-term impacts on forested areas exposed to condensate and other well emissions beyond the burned area, Amoco (Ecosat) used observations on vegetation impacted by the 1977 blowout as an analog. It concluded that where condensate precipitation is heavy, as in the regions shown on Figure 8.1, tree mortality would be high. Further extrapolations indicate that retarded growth will occur in other less impacted areas for a period of 2 or 3 years before resuming normal growth.

On the strength of the Amoco information and its own observations, AFS similarly concluded that survival and growth of mature trees in the moderate to heavily condensate-exposed areas would be very limited. To facilitate reforestation and to reduce fire risks, AFS required Amoco to clear-cut the areas over some 290 ha as shown on Figure 8.2 and further clearing may be required. In those regions, a reforestation program, as part of the general reclamation program for the area, is being conducted by Amoco under the guidance of AFS.

Amoco (Legge) also investigated the potential impact of sulphate-sulphur ($SO_4 - S$) beyond the observed condensate regions. Amoco (Legge) concluded that the forest ecosystem had been subjected to elevated levels of surface sulphate and that short-term modification of nutrient cycling would occur. The results would be a short-term interruption in growth rates, 2 to 3 years, as observed in similar forest areas around the 7-10 well blowout in 1977.

It is obvious that there was a major impact on forest and other vegetation in the immediate well-site area. However, apart from the heavily impacted areas shown in Figure 8.4, the Panel concludes that actions to date and planned programs will permit successful reclamation and revegetation of all areas of the site. Indeed, early observations indicate that forest recovery at the perimeters of the burn were already starting by natural reforestation much like that which occurs in a typical forest-fire burn area. For the heavily impacted areas near the well, the Panel accepts that the planned reclamation programs will ultimately be successful, though it will take many years to fully confirm that expectation.

8.3.2.3 Groundwater

Amoco stated that a considerable quantity of condensate, estimated at 18 000 to 19 000 m^3, settled onto the ground during the non-burning periods of uncontrolled flow. Since the well was located only some 350 m from Zeta Creek there was a significant potential for condensate flow into, and for contamination of, Zeta Creek and the nearby Pembina River. In addition to accumulation and flow over the surface, Amoco observed that the condensate moved laterally at some speed through fracture planes in the bedrock and seeped out at exposed bedrock faces near Zeta Creek. When this was detected, Amoco constructed a series of trenches and berms to intercept and burn off the condensate before it could reach Zeta Creek or the Pembina River.

Soon after the well was capped, Amoco drilled 74 observation boreholes to initially evaluate surficial geology and the presence of condensate in surficial groundwater aquifers. Subsequently, Amoco installed permanent casing in 54 of these to serve as piezometers to observe groundwater hydrodynamic gradients (which indicate direction of flow) and monitor changes in condensate contamination of the groundwater. Amoco concluded that possibly 1900 m^3 of condensate migrated into the shallow aquifer system. As well, it observed that there was relatively rapid migration toward the interceptor ditches following hydrodynamic gradients interpreted as shown in Figure 8.5. Except for trace amounts of condensate that may have migrated into deeper aquifers, Amoco did not foresee groundwater contamination as a future problem. However, it planned to maintain observation wells for several years until such time as it could be confirmed that no more than trace amounts of condensate were present in the local groundwater system.

The Panel notes from the table of well emissions that Stage 3 represented the most likely period for condensate contamination of the groundwater, both because of the volume of condensate that fell and also because the earlier fire had removed the snow and ice and thawed the ground. If half of the total amount settled onto the nearby burned land area and possibly one-third of that amount actually reached the aquifers, the total contamination would be some 2000 m^3. It appears to the Panel that groundwater contamination is localized near the well, can be corrected over a period of time, and is not an immediate problem because of the isolated location of the well. The Panel endorses Amoco's plans to maintain the piezometers and condensate-capture trenches for several years until the condensate is eventually dissipated and does not represent a groundwater hazard.

8.3.3 Surface Water and Aquatic Organisms

8.3.3.1 Surface Water

During the Stage 1 phase of the blowout, condensate precipitates reached both Zeta Creek and the Pembina River. This contamination problem was immediately reported to water users downstream (eg, Evansburg) and alternative sources for domestic water were instituted. Amoco took action to reduce condensate effects during the blowout, after capping, and before the spring thaw by cleaning up the site and river ice, installing spill-control booms, gravel berms, and culverts on Zeta Creek, and containment trenches to avoid contamination of surface water. The accidental ignition of the well during two extended intervals resulted in burning off much of the emitted condensate that lay on the surface in the immediate well-site area. From the viewpoint of minimizing long-term contamination of surface water, this burning off of surface accumulation of condensate proved to be a great advantage. Amoco (Stanley – IEC) reported that the water used to control ground fires and high ground temperatures near the well also tended to flow into the creek and oxbows near the well. These represented significant sources of contamination of surface waters. Subsequent observations showed that, apart from a short-term peak in hydrocarbon level which moved out with spring break-up ice, the river is now virtually free of hydrocarbons. Respecting Zeta Creek, Amoco has installed a dam and culvert water-release system that will allow surface skimming of any condensate that may be washed into the creek.

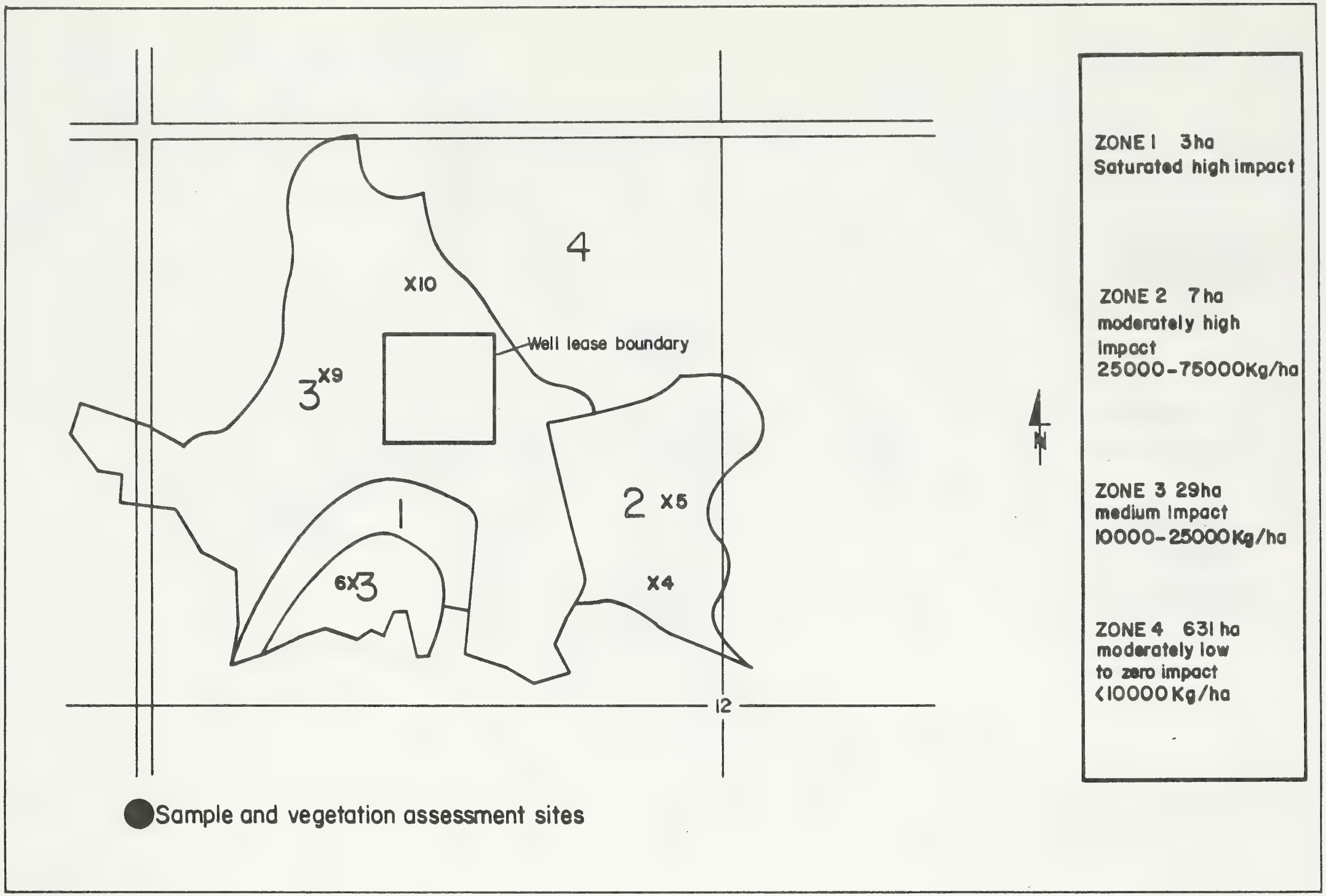


FIGURE 8.4 CONDENSATE IN SOILS AROUND THE 13-12 WELL.
Reproduced from Exhibit No.173.

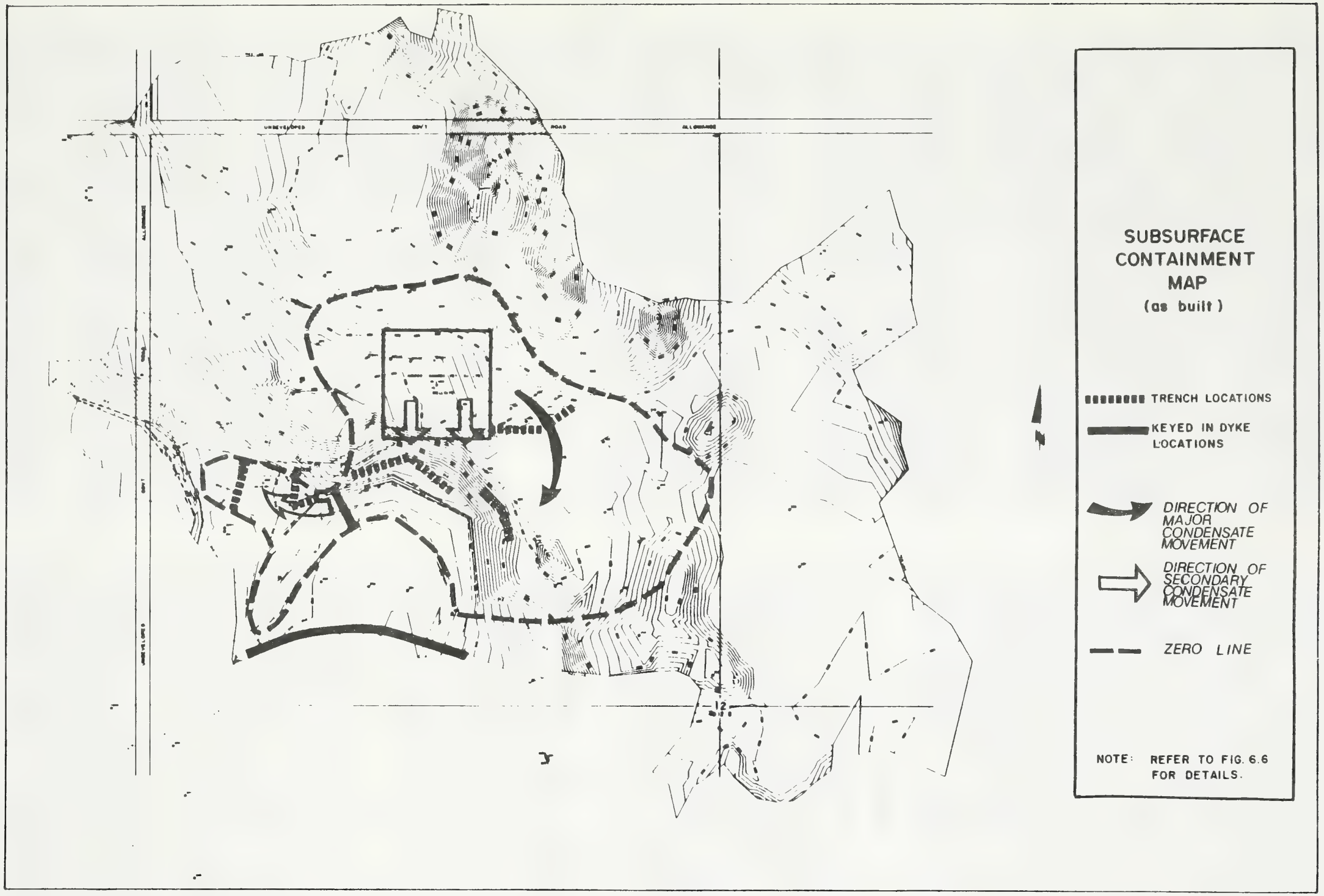

SUBSURFACE
CONTAINMENT
MAP
(as built)
TRENCH LOCATIONS
KEYED IN DYKE LOCATIONS
DIRECTION OF MAJOR CONDENSATE MOVEMENT
DIRECTION OF SECONDARY CONDENSATE MOVEMENT
ZERO LINE
NOTE: REFER TO FIG. 6.6 FOR DETAILS.
12

FIGURE 8.5 CONDENSATE IN GROUNDWATER AROUND THE 13-12 WELL.
Reproduced from Exhibit No. 95.

The Panel is satisfied that measures to protect surface water were reasonably successful since participants stated that hydrocarbon contamination of the surface water bodies, initially detected as far downstream as Evansburg, disappeared in a few months.

8.3.3.2 Aquatic Organisms

Owing to the winter season, fish and benthic studies had to be deferred until spring, several months after the well was capped. Amoco (Stanley – IEC) found little evidence of negative effects on fish spawning. However, waxy-condensate precipitates were found in some creek muds, and these could adversely affect local populations of small benthic organisms.

Benthic organisms collected at various sites along Zeta Creek and the Pembina River showed some initial changes in species diversity, but these changes disappeared later in the year. Amoco stated that, while periodic monitoring will continue, observed effects on aquatic organisms have been relatively mild and are expected to be very short term.

The Panel believes that, while techniques such as measuring species diversity rely on some rather loose assumptions, it is probable that the effects of the blowout on benthic organisms, primarily from condensate contamination, would be very short term and should no longer be of concern. Nevertheless, the proposed monitoring surveys should be helpful in confirming those preliminary observations.

8.3.4 Wildlife

While the evaluation of wildlife impacts focused on the "on-site and immediate area", observations respecting larger ungulates necessarily extended farther afield. Amoco reported that during the blowout, three moose and a raven were found dead near the well site. The moose were found 500 m from the well in the burned area shortly after the first fire. Cause of death was not established. Amoco inferred from animal track surveys that large ungulates such as elk were avoiding the immediate well-site area during the winter but otherwise, ungulates moved about the forested areas beyond the immediate area in patterns that conformed with surveys of the general area done in 1981. A small mammal survey carried out by AFW in the cleared and perimeter areas determined a shift in species composition, probably temporary, but with no significant changes in numbers. Captured fur-bearing animals were unaffected.

The Panel believes that wildlife impacts in the on-site and immediate area, especially within the burned area, were significant. As well, the cleared area (Figure 8.1) can be expected to show changes in wildlife species diversity because of alteration of the habitat. The Panel questions whether the findings and conclusion from the AFW survey are consistent with the evidence of the local area residents when they reported on numbers of birds and wildlife, as well as effects on their livestock. The small mammal survey was restricted to an area within 3 km of the well, whereas the residents' evidence related to impacts as distant as 55 km. There is no evidence available to the Panel to examine these apparent differences. Moreover, it would not be possible to determine whether wildlife experienced the specific effects identified for livestock in the general area. Consequently, the Panel can only identify this potential discrepancy in the evidence. In any event, the Panel believes that long-term impacts on wildlife will not be adverse in a significant way though condensate-exposed forests may cause some minor adverse effects on small animals and birds for a number of years.

8.4 Local Regional Area

With respect to the area beyond a radius of some 5 km from the well, evidence concerning impacts related to only a few specific items. These primarily related to assessing effects on human and animal health and on personal property, including domestic animals, deriving essentially from air pollution caused by H_2S and SO_2 emissions during the 67-day blowout period. Potential human health effects are discussed separately in section 7 and will not be addressed in this section, but impacts on personal property are reviewed.

Amoco (Promet) developed a continuous air-shed modelling program which it combined with intensive local plume monitoring and information from monitoring sites in various parts of the province as a means of evaluating airborne environmental pollution from the well. The results aimed to show daily changes in H_2S or SO_2 over the province as a result of regional atmospheric air flows.

PAC also performed an extensive post-event study of potential sulphation impacts on the local region, using both plume-modelling and local region ground sampling and evaluation methods. AE endeavoured to evaluate the significance of both the Amoco air-shed modelling and the PAC evaluations in relation to AE's own special knowledge in plume dispersion modelling.

The Panel notes that there was a significant degradation of air quality over a very large area during the blowout. This was especially noticeable to the public during Stages 1 and 3 when raw sour gas was mixing in the atmosphere and being carried far afield. However, beyond what the Panel has classified as the local regional area (ie, up to 60 to 70 km from the well), the Panel believes that most of the biophysical and personal property impacts of this air pollution would have been of the nuisance variety.

8.4.1 Air

A wide area around the well site was exposed to airborne pollutants, specifically H_2S, SO_2, other well gases, and condensate. An analysis of condensate deposited on the ground, carried out several months after the well was capped, showed the condensate to be composed of 62.4 per cent alkanes and 37.6 per cent aromatics and other compounds. The alkanes are believed to be rather rapidly biodegradable, but the aromatics are more difficult to break down. Amoco estimated that 40 per cent of the condensate evaporated into the atmosphere during the blowout. The nature and fate of the evaporate-component were the subject of speculative questions during the inquiry: ie, what were its components?, would concentrations be sufficient to have adverse influence on the air?, would it have noticeable effects on humans or animals if breathed in?, etc. However, there was no evidence presented to evaluate these questions.

Respecting effects from the plume, the Panel is inclined to accept that the focus of ground level impacts, if measurable, would tend to be within an area 60 to 70 km from the well as outlined by PAC (Figure 8.3). Anecdotal evidence from local residents support that concept. At the same time, the Panel understands that mixing of the plume in the upper atmosphere and long-range transport of it to remote regions as calculated by Amoco (Promet) is a reasonable and widely accepted meteorological proposition. Odour complaints hundreds of kilometres from the source also tend to verify that concept.

PAC focused its attention particularly on possible cumulative sulphur deposition in the local region that could be caused by plume impingement on the ground. PAC assumed a total sulphur emission rate of some 485 tonnes per day based on an assumed raw gas rate of 1.1×10^6 m^3 per day and 30 per cent H_2S. Using the SULDEP Model, it predicted that sulphation impingement would range up to 35 kg/ha in a region as shown in Figure 8.3. From ground sampling focused in an area easterly and southerly from the well, PAC first believed that it had generated a reasonable corroboration of calculated plume-impingement sulphation using ground leaf litter sample data. It later acknowledged that there were problems in sampling and measuring that made interpretation of results complex and potentially ambiguous.

AE contended that PAC had erred by introducing forced, abnormally high deposition velocity rates in the SULDEP Model. AE implied that the proper velocities, considering the presence of snow cover and relatively cool, arid, winter conditions should have been only perhaps one-seventh those assumed by PAC. If so, the calculated sulphur fall-out and retention in the high-impact areas would then be calculated as possibly only 2 to 5 kg/ha, rather than 15 to 35.

Though Amoco (Promet) did not specifically examine the question of cumulative sulphur deposition in the local region, its air models showing daily changes indicated that the bulk of the well emissions were being lifted and mixed largely in the upper atmosphere (300 to 500 m above ground level) and being transported over hundreds of kilometres from the site. By inference, sulphur fall-out in the local region would have been modest and not likely of measurable impact on the local regional ecosystem.

The Panel has considered potential maximum ground-level concentrations of SO_2 including provision for plume momentum rise. From these, the Panel concludes that maximum ground impingement would probably occur from 10 to 20 km from the well. This is similar to areas that PAC has described as having maximum sulphation impact in a local region as shown on Figure 8.3. Respecting leaf litter sulphation sampling, the Panel believes that the PAC programs would have to be subjected to more extensive evaluation to establish whether it is an effective means of evaluating such impacts. The Panel believes, taking into account the low adsorption possibility for the winter season, the PAC calculations overstate the cumulative sulphation effect and that the actual levels of cumulative sulphation impact would be significantly less than predicted by PAC.

In summary, the Panel believes that ground-level sulphation from the 13-12 blowout, because of the winter season, would not likely have had measurable effects. Within cultivated land areas, even if loading was as high as the values submitted by PAC, crop uptake in the subsequent summer growing season would have had a very good chance of masking incipient soil acidification effects. Also, because the emissions occurred in the non-growth winter season, indirect assessment of sulphation by measuring possible damage to natural vegetation is essentially eliminated.

In spite of those conclusions, the Panel believes there are two aspects of the subject that warrant further pursuit. The Panel recommends that the ERCB and AE consider sponsoring a symposium to hear expert views on the two general subjects of plume modelling/plume impingement and sulphation ground sampling analysis techniques. Bringing concerned members of the public, including those with agriculture, forestry, and general environmental interests, together with meteorological, biological, and soils experts would seem to be a worthwhile follow-up to this most significant sour gas blowout event.

8.4.2 Personal Property

8.4.2.1 General

The question of possible financial losses by local residents was expressly excluded from consideration under the terms of the inquiry. Amoco advised that a number of claims for personal property damage were being paid by Amoco and other claims were in litigation.

Anecdotal evidence was presented by several local area residents regarding effects on buildings, machinery, equipment, fences, crops, and livestock from the blowout emissions. These impacts were thought to be due to H_2S when the well was not on fire. There was also speculation on possible problems from other pollutant components in the raw gas and some reference to potential longer-term effects from sulphur deposition on soil.

Several participants testified that the paint on their buildings turned black, which would be consistent with a reaction between H_2S and certain paints. Evidence was also given that silverware was blackened, electrical contacts were corroded, some machinery became non-operational, and fences were discoloured. The Panel recognizes that these effects, which occurred during the blowout phase, constitute an annoyance and some financial loss to residents. The Panel believes that since the cause has been removed, no further effects are likely.

8.4.2.2 Crops

Testimony on the effects of the blowout emissions on crops was scarce. Since the blowout occurred in winter, no growing field crops were affected, though it was reported that some houseplants died. There was evidence from local farmers that in the following summer, alfalfa and hay crops were as low as one-half to two-thirds normal yields. Some suspected there were direct adverse effects from the well emissions. Countering this view, AA submitted that seasonal factors such as low moisture and adverse growing season temperatures were more likely the causes of the reduced productivity observed in 1983. The Panel notes that a very comprehensive protocol would need to be in place before and after the blowout event in order to confirm, even qualitatively, such effects, because weather and agricultural practices have a gross masking effect on crop performance. The Panel believes that sulphur deposition rates were such that possible adverse effects would not likely extend beyond one growing season.

8.4.2.3 Livestock

The question of airborne well emissions from the blowout and their effects on livestock received considerable attention at the inquiry. The Panel did not receive detailed evidence on individual claims for losses due to such effects because evaluation of such claims was outside of the terms of reference. However, the Panel did hear considerable evidence respecting the general impact of the blowout on livestock from a number of those who appeared on behalf of PASGEC, and from individuals appearing at the informal session in Drayton Valley.

Many of the signs of physical distress described in animals had some similarity to the human symptoms described by those appearing at the inquiry. For that reason, a description of the signs was presented in section 7.2.4 of the report and is not repeated here. The Panel recognizes that a number of the individuals appearing at the inquiry referred to effects on livestock. These included spontaneous abortions or other effects on the birth rate or weight and quality of newborn calves, weight loss in mature animals, and reduced milk production. Although some of the participants presented documents to support their allegations, the Panel does not have sufficient information to draw definite conclusions respecting the effects. For example, one witness presented milk delivery statistics which revealed a reduction in milk production for his dairy herd, but data respecting all other variables which could affect production were not available. Thus, a sound scientific conclusion could not be reached regarding the possible financial effect of the blowout on the dairy herd in question.

In another matter related to livestock, staff of the Alberta Environmental Centre attempted to determine the effects of the emissions on certain important enzymes of cattle. Blood samples were taken from cattle from ten herds in the affected area during the blowout and subsequent to the capping of the well, and also from two control herds in the Vegreville area.

These studies showed that some statistically significant biochemical perturbations did occur in animals within the exposure area. In all cases, however, the changes appeared to be transient and reversible. The investigators advised that these results are highly experimental in nature and must be interpreted with considerable caution, particularly when assessing suspected clinical disease in the animals. At present, the importance of these results is not known.

8.4.2.4 Financial Compensation for the Public

There is no mention in the terms of reference for the inquiry of the question of the monetary impact of the blowout on the public and the Panel clearly does not have jurisdiction to determine whether such impacts occurred, or whether compensation should be paid.

For this reason, the Panel and most participants avoided discussing these matters, but compensation was nevertheless referred to on a number of occasions by participants from the public during both the formal and informal sessions. These comments and the many references in the media to the subject prompts the Panel to comment on it in a general way in this report. However, the Panel is not expressing any opinion as to whether the monetary impacts referred to at the inquiry as a result of the 13-12 well blowout were real or otherwise.

There is no question that monetary impacts can result from sour gas blowouts and that some of these were imposed on members of the public. Indeed, Amoco indicated that it had voluntarily settled several damage claims and that others were under negotiation. The comments from members of the general public indicated that problems stemmed from the determination of whether damage had been incurred and the long delays in settlement. In the Panel's judgement, part of the dissatisfaction of the public regarding sour gas blowouts is because there are real or perceived monetary impacts and nuisances which might not be compensated. Many spokespersons for the public suggested that these concerns would be rectified if the industry was forced to carry no-fault third-party damage insurance. The Panel questions whether this would be the case but recognizes that there is a problem which should be considered. The Panel recommends that the ERCB, the industry, and appropriate Government departments give this matter further consideration and notes that the matter of blowout insurance is currently being examined as a follow-up to recommendations in the Phase 2 report.

8.5 Reclamation

Only the immediate area around the well site is likely to require reclamation. Evidence was presented on the sulphur deposition beyond the immediate area, but effects were stated to be small or negligible. Nevertheless, the Panel believes that soil and vegetation should be monitored for several years for at least 10 km in the downwind directions from the well site.

The burned-off soil area next to the well and the clear-cut area extending several more kilometres are planned for reclamation. Seedlings were being prepared in 1983 for planting in 1984. Soon after the well was capped, a committee was formed to co-ordinate damage evaluation and rehabilitation chaired by the ERCB with AFS and AE having key roles. This committee approved or requested some site clean-up measures, and at the time of the inquiry, Amoco was working with the committee to develop long-term reclamation plans. The Panel understands that Amoco's reclamation activities under direction from this committee are well under way.

8.6 Summary of Panel's Views

Significant short-term environmental effects from condensate, H_2S, and SO_2 were experienced during the blowout period, particularly in the area closest to the well.

On and near the well site, over an area of about 300 ha, there were major impacts on vegetation and soil, and lesser impacts on surface water, groundwater, benthic organisms, mammals, and birds. Some of these impacts were ameliorated by quick remedial actions.

Due to the large quantity of condensate on the vegetation and in the ground, there will continue to be impacts near the well site for some years on trees, groundwater, soil, and benthic organisms. Again, remedial steps have been taken to reduce some of these impacts.

To overcome the major impacts in the vicinity of the well, a program of short-term remedial measures and longer-term reclamation has been established. The program is comprehensive and should permit successful environmental rehabilitation of the impacted area.

Sulphur emitted from the well, primarily in a gaseous form, was eventually deposited on the ground over an area of hundreds to thousands of square kilometres. Although the evidence submitted on the rate of deposition was conflicting and none of the estimation methods available are scientifically proved, the Panel believes that even in the more heavily impacted area within a radius 60 to 70 km around the well, the extent of sulphur deposition was relatively low. There is no evidence that these levels of sulphur deposition would have measurable harmful effects on soils, vegetation, or water bodies.

There were effects during the blowout on personal property, some being tangible and others in the form of nuisance effects. Effects on livestock, in particular, were observed during the blowout phase, but severe short-term or long-term effects are difficult to prove. Human health effects are dealt with in section 7.

8.7 Recommendations

The Panel makes the following recommendations with respect to environmental matters.

1. AE and other appropriate Government departments should establish a protocol for improved sampling and analysis of soil and vegetation that would provide a means of evaluating impacts of sour gas releases on soils and vegetation if a blowout occurs in future.
2. AFS should co-ordinate long-term monitoring of impacts on the biosphere in the "on-site and immediate" area of the 13-12 well, plus adjoining areas of the blowout, as defined in this report.
3. AA should develop a protocol to enable the gathering of timely and relevant data on agricultural activities if another serious sour gas release occurs.
4. AA should consider conducting an on-going examination of livestock in the general blowout area to determine if effects of long-term exposure to H_2S can be found.
5. The ERCB, the industry, and appropriate Government departments should consider ways of dealing with concerns of the public respecting monetary impacts on the public resulting from sour gas blowouts.
6. The ERCB and AE should arrange a symposium to hear expert views on plume modelling/plume impingement and sulphation ground sampling analysis techniques.

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Well-site workers' discussion.

Photo courtesy Standard Safety & Consulting Services (1978) Ltd.

9 COMMUNICATION AND CO-ORDINATION

9.1 Introduction

PASGEC, as well as other participants, expressed serious concerns about the extent to which the public had been kept informed about the blowout and its impacts. They contended that the communication efforts had been totally inadequate and, as a consequence, the public had been subjected to fears about their safety and health and had not been provided with information necessary to make reasoned decisions about whether to leave the area or not. Moreover, PASGEC contended the inadequacy of the information conveyed, and the perceived reluctance to provide information to the public, led to misunderstanding and distrust by broad segments of the public of those in authority over the blowout. PASGEC contended that much of that misunderstanding and distrust occurred because the media were left to provide most of the information and their reports were designed to provide a “story” rather than facts. Consequently, reports were sometimes contradictory.

The ERCB and several Government departments conceded that neither their individual nor combined efforts to inform the public about the blowout had turned out to be satisfactory. They generally recommended that different procedures should be followed to better inform the public should a similar event occur in the future.

In a somewhat similar vein, various participants in addition to PASGEC expressed concern regarding the effectiveness of co-ordination of activities by parties having responsibilities respecting the blowout. It was alleged that jurisdictions overlapped, actions were sometimes contradictory, no single party was clearly responsible, and overall, actions were less than satisfactory.

The primary emphasis for these allegations of inadequate communication and co-ordination related to the protection of the health and welfare of the public.

In this section, the Panel reviews the communication efforts by each of the parties, assesses their effectiveness, and makes recommendations. Similarly, it reviews the effectiveness of co-ordination between parties and recommends certain changes.

9.2 Communication with the Public During the Blowout

9.2.1 Amoco

Amoco indicated that it had provided information to the public through the mass media either formally, by press releases, or informally, through telephone contact and interviews with the media. Also, it had stationed a public affairs specialist in Drayton Valley during the blowout to assist in its program.

In terms of formal contacts, Amoco issued 33 news releases, held 6 press conferences, and responded to numerous media inquiries. It also arranged for a fly-over of the site and three visits to it by media representatives, released film footage from the site, and had the company president appear on a television phone-in question-and-answer program. Amoco explained that it initially reported only significant happenings at the site, and since little was taking place on many days due to weather or other problems, Amoco reduced its media contact. It said that during these periods there was no news to release and so nothing formal was done.

After possible health effects became a serious issue, Amoco began making daily news releases concerning the well and also issued statistics related to absenteeism at its Drayton Valley office, which were intended to demonstrate that detrimental health effects were not occurring. At this time, Amoco did not have on-site medical experts specializing in the effects of H_2S on human health. It made information available respecting work standards for H_2S exposure in an effort to illustrate that health standards were significantly different than environmental standards. Amoco was critical of the media for emphasizing the ambient air quality standard, of 0.01 ppm H_2S for a 1-hour exposure, when reporting the results of monitoring for H_2S levels related to the blowout.

Immediately following the blowout, on 18 October, Amoco personnel and RCMP officers visited residents of Lodgepole and informed them of the situation and the possible need to evacuate. They also informed farmers and personnel at work sites in the area, such as petroleum plants or lumber mills. On 23 November, when H_2S levels at Cynthia were increasing, Amoco initiated notification of residents of the possible need to evacuate, but ceased notification before it was completed as H_2S levels declined.

Amoco set up a 24-hour phone system, manned by senior personnel, to receive complaints; however, it did not advertise the number as it believed Amoco was well known in the area and could be easily contacted. It made arrangements for monitoring equipment to be dispatched to particular areas when complaints were received reporting strong odours, and attempted to provide assurance and advice in response to general complaints. Amoco indicated that when it contacted residents in the area close to the well, it advised them that if they had special health problems, they could move to Drayton Valley or Edmonton and be accommodated at Amoco’s expense.

9.2.2 ERCB

The ERCB issued a fire-hazard order on 19 October and arranged with AFS to have it notify known forest users such as campers, trappers, and timber operators.

In terms of communicating with the public, the ERCB staffed its Drayton Valley office 24 hours per day during periods when the well was not on fire to respond to complaints about H_2S odours. It initially referred incoming complaints to Amoco, but as the number increased, it began to register them prior to notifying Amoco, and recontacted the complainant in an attempt to better deal with the matter.

The ERCB acknowledged that it did not have a planned information service available during the blowout. The only press release it issued was on 26 November, more than half-way through the blowout period. At that time, it announced that Amoco would be given one more opportunity to cap the well and if this was not successful, the drilling of a relief well would be ordered.

9.2.3 AE

AE played the lead role in terms of communicating with the public by Government departments and agencies. It issued the first of 14 press releases on 19 October and they were issued fairly regularly during the periods when the well was not on fire. In response to questions respecting the distribution of the press releases, AE said they were released to the general government distribution service.

AE did not review the wording of its press releases with other Government departments or agencies nor did it know if others were issuing releases. AE considered that it was making a reasonable effort to convey information to the public through its press releases, responses to telephone inquiries, individual responses to media inquiries, and press briefings or interviews. It did state, however, that an improved system for communication with the public should be developed for possible future emergencies.

AE also made a telephone number available to the media so they could obtain recorded data about H_2S concentrations in the city of Edmonton. It also has a complaint number which is listed with other emergency numbers in the telephone directory, but AE did not specially advertise that number in newspapers or on the radio during the blowout. It received 1438 complaints during this 67-day period, compared to 300 to 400 in a typical year. AE relayed general information respecting H_2S in response to the complaints as well as referring calls to SS&CH, family physicians, and the Medical Officer of Health.

AE contacted downstream users of water from the Pembina River with respect to the blowout. It did not provide specific monitoring details to residents in the area, including Cynthia during the 22 and 23 November incident when relatively high readings were occurring. It did, however, conduct a follow-up survey in the area on 26 November to see how effective the contact system had been during the incident.

9.2.4 SS&CH and PBOH

SS&CH did not issue press releases during the blowout as it knew AE was doing so and believed that limiting public releases to only one government source might avoid confusion. It did, however, have several interviews with the media, and wrote one letter to the editor of an Edmonton paper to correct misinformation on health standards. SS&CH received 1477 calls, mostly relayed from AE, which were responded to by an official of SS&CH.

A booklet on health information and H_2S was prepared by the PBOH as a result of the blowout, but it was not available until after the blowout. Also, officials of the department visited the area to make information on health available, but again, after the blowout.

SS&CH acknowledged that it could have done a better job of making health information available to the public.

9.2.5 Other Government Departments and Agencies

AA did not have extensive contact with the public during the blowout but responded to the 10 to 15 inquiries it received. It did not issue press releases or provide any information regarding the effects of the blowout on animals during the period in question, except on request. Two division veterinarians visited several farmers in the area on 2 December, and an official discussed H_2S toxicity in animals at a meeting in the area in February of 1983 after the well had been capped. Alberta Disaster Services (ADS) indicated that it received only a few calls and AFS stated that it assisted in notifying forest users of the blowout. None of the other Government departments or agencies reported communications with the public during the blowout.

9.2.6 Others

The Alberta West Central Health Unit (Health Unit) received telephone complaints and gave advice where possible. Its health inspector and health nurses were frequently in contact with the citizens in the area, and conducted a number of clinics during the blowout. The Health Unit gave advice on health, referred individuals to physicians, and in some instances advised leaving the area. It also gave media interviews on request, both during and after the blowout.

The Town of Drayton Valley contacted schools and hotels and notified them of the emergency. It did not inform the residents of the town that evacuation was only a remote possibility.

The RCMP responded to calls and referred questions respecting news of the event to Amoco. On 18 October, it notified residents of Lodgepole of the blowout, and was prepared to assist in evacuations if necessary.

9.2.7 Media

As would be expected, the media was the main source of direct information for the public during the blowout. The Panel has analysed several hundred news clippings generated during that period in an effort to determine if there was a pattern in the number of stories and in their messages.

In the days immediately following the blowout, the event was being reported primarily as a news item and although there was a recognition that the well was blowing sour gas, there was not a concerted effort to address potential health effects. Most news reports indicated that capping of the well could be expected within days. As the blowout continued and the odour became noticeable more frequently for larger numbers of people, the emphasis of reporting shifted towards questioning what went wrong at the well and whether health effects would result from the sour gas being released. When the well caught fire for the first time, the fire itself and the manner in which it occurred were news stories but the reporting on health effects of the blowout appeared to decrease.

The situation changed substantially after the fire had been extinguished to allow capping efforts to continue and two Wild Well fighters died from H_2S poisoning. The deaths themselves were a major story, and there was a further increase in the number of stories and the level of questioning and skepticism respecting the handling of the entire matter. The frequency of blowout stories appeared to be about double for the period following the deaths on 16 November as compared to the previous period. A further tragic death in the area due to exposure and in no way caused by the blowout, nevertheless, had the blowout as a background in many of the news reports, thus increasing public awareness of the problem.

In the period following the workers' deaths, conflicting stories respecting effects, particularly on health, became more frequent. Information about previous H_2S related deaths in Alberta and elsewhere were being published, and with no central source of good information available, some of the stories were contradictory and at least confusing, if not inaccurate. This likely occurred because many of the statistics used in the stories were obtained by informal contacts with individuals, some of whom might not have had access to the kind of information being sought.

Many claims and counter claims by experts were being reported and the resulting confusion and increasing concerns on the part of the public increased the importance of stories on the blowout and on H_2S. Much of the reporting during this period dealt with health standards and there was confusion respecting environmental standards, occupational standards, and standards for sensitive individuals. Some doctors were being quoted as indicating that a serious health problem existed, at least for certain individuals, while others were claiming there was no long-term problem.

Reporters during this period appeared also to emphasize to a much greater extent questions as to the cause of the blowout, the performance of Amoco in drilling wells, and the adequacy of the ERCB's control regulations and its enforcement of them. Stories of this nature continued after the blowout was controlled as pressure mounted for a full public inquiry into the matter.

Mr. Struzik, a reporter with the Edmonton Journal at the time of the blowout, appeared at the inquiry. He indicated that he had made serious efforts to obtain all possible information but that Amoco was more difficult to obtain information from than is usually the case in major news events. He also said he contacted many doctors and agencies respecting health effects and standards, and reported the information given to him even when it was conflicting. When questioned, he admitted he did not attempt to explain the difference between the ambient air standards and the occupational exposure limits for H_2S. Mr. Struzik acknowledged that he did not have technical expertise in the subject matters he was reporting on, but suggested that this was not essential to proper reporting. He pointed to a serious lack of co-ordinated communications on the part of Amoco and government officials as a serious deficiency in reporting on the blowout.

9.3 Assessment of Communication Efforts

The evidence presented at the inquiry amply demonstrates the serious communication problems experienced by the public during the blowout, and the consternation experienced when the well was emitting H_2S gas. For those living in the immediate area, and to a lesser extent those residing in more distant centres, the emissions frequently caused offensive odours, which for many led to nausea and the other health-related effects described previously. In addition, the public was conscious that under certain circumstances the emissions could be lethal, but very little specific information was provided about safe limits and how these were being monitored and controlled. Of particular concern to the public was whether special precautions should be taken for individuals considered to be more sensitive, such as the very young or old, those suffering from respiratory ailments, and pregnant women.

The Panel notes that both Amoco and AE issued many press releases and were attempting to communicate with the public. However, the information provided respecting possible health effects was general and to some extent required acceptance that the public's interests were being fully cared for. The information frequently did not satisfy the public since it was not sufficiently specific to permit individuals to make their own decisions about whether they were at risk and whether or not they should be taking appropriate action. A complicating factor was that the media reports were sometimes "sensational" and tended to increase concerns rather than increase knowledge and, therefore, understanding. For example, the article titled "Danger lurks in darkness in pursuit of toxic cloud" did little to inform the public. It stated the concentrations were "... 1400 times above the provincial acceptable standard". It did not explain that the "acceptable standard" was based on the odour threshold and not on health factors and that the maximum concentration referred to in the article was only slightly higher than the occupational health standard exposure limit of 10 ppm for an 8-hour period.

While those persons living in the immediate area of the blowout were generally aware that monitoring operations were being conducted, they did not receive specific information about the monitoring program or its results. Consequently, they were completely dependent upon the company, the Government departments and agencies, and the media for information of the situation as it changed from day to day.

The Panel agrees with the consensus of inquiry participants that the communication program was deficient and that, in the event of another blowout, a more open and informative approach should be adopted. Moreover, the Panel believes that for the communication program to be effective in any situation involving the public to such a major degree, there must be provision for two-way communication. In other words, not only is it necessary for the public to understand the plans and actions of those responsible for regaining control of the well and protecting the public, it is also necessary for those in charge to understand, appreciate, and respond to the concerns of the public. In an incident such as the Lodgepole blowout, the Panel believes steps should be taken to ensure that there is a mechanism whereby those making decisions are fully aware of public concerns. Indeed, that information is a vital ingredient in assessing alternative courses of action in regaining control of the well. Had all of the information respecting public concerns been available during the Lodgepole blowout, the decision to cap the well while it was on fire might have been taken earlier, thereby reducing the fears and concerns of the public. The Panel believes it significant that the reaction by the public to the blowout seemed to be greater during the second period that the well was not on fire than during the first period. If the decision had been made to cap the well while it was on fire at that time rather than extinguishing the flame, many of the concerns and problems that subsequently developed might have been avoided.

Finally, the Panel believes that special efforts must be made to ensure that the media is fully informed in order that it can properly carry out its essential role in informing the public. A well blowout is almost certain to be news and should be treated in that manner with special communication services and facilities. Otherwise, communication difficulties most certainly will develop.

9.4 Recommended Communication Program

The Panel agrees with PASGEC that:

> "The more relevant events and decisions are, the greater the need for effective communication. Events are made more serious, and relationships are strained and upset, when there is no communication, communication is of poor quality, or is inadequate."

A well blowout which results in the emission of large volumes of H_2S gas is a very significant event for the people that may be affected by it and therefore requires a carefully planned two-way communication program. Furthermore, because of the need for immediate action in the event of a sour gas blowout, the Panel believes that a communication program should be ready so that it can be implemented immediately. Based upon the views expressed at the inquiry, particularly by participants from the general public, the Panel believes the communication program should provide, at a minimum, the following kinds of information:

(a) details of the blowout, plans for regaining control of the well, and progress reports on control efforts,

(b) details of emissions from the well and how they might impact on the public, both from a safety and a health point of view, as well as nuisance and discomfort,

(c) details of safety and health standards and the basis for them,

(d) details of all monitoring programs and the results, and

(e) details of evacuation plans, the basis for them, and how they would be carried out.

Additionally, the program should be structured to include:

(a) provision for advice and consultation for citizens concerned about special situations,

(b) arrangements for input by the public, and

(c) arrangements for the media to become better informed.

The Panel believes that steps should be taken by the appropriate Government departments and agencies, together with representatives of the industry and the public, to develop a detailed communication program. It would incorporate the above objectives and could be implemented immediately in the event of another serious blowout.

Because of the experience gained by PASGEC during the 13-12 incident, the Panel recommends that representatives from that group be included as public participants in the planning exercise. Additionally, the evidence given at the inquiry should be reviewed in detail because of the many suggestions put forward at that time.

9.5 Co-ordination of Responsibilities and Activities by Government Departments and Agencies

Government departments and agencies that had some level of jurisdiction in the 13-12 incident included: ERCB, AA, AE, ADS, OH&S, SS&CH, PBOH, E&NR, RCMP, County of Parkland No. 31, Improvement District No. 14, County Police, Town of Drayton Valley, Alberta West Central Health Unit, and the Drayton Valley hospital.

Co-ordination of work at the blowout site appeared to be effectively handled but evidence at the inquiry indicated a potential for confusion with respect to:

(a) the monitoring program,
(b) establishment of health standards,
(c) evacuation of residents,
(d) ignition of the well, and
(e) communication with the public and media.

In the case of the 13-12 incident, the Panel believes that while the potential for confusion and contradiction existed, the extent to which they actually occurred was minimal even though media reports dispute this. On the other hand, they were perceived by the public to be rather significant at times, primarily due to the poor communication system. While areas of responsibility may not have been defined with precision at all times and communication of the situation to the public was less than ideal, the co-operation between the departments and agencies was generally effective. Nevertheless, the Panel believes that this question should be addressed further.

Several of the participants suggested that the best way of avoiding potential problems would be by the establishment of a single command post through which all activities involving the public would be funnelled. The Panel supports that concept. The disaster plan recently approved and circulated by the Government, "Peacetime Emergency Operations Plan For a Sour Gas Release", developed by ADS, incorporates this concept and provides for the ERCB to be the co-ordinating body. The document is included in the report as Appendix 8. The single command post provides a clear, well defined means of furnishing information and responding to questions by both the public and the media. Within the government service, it similarly provides an effective co-ordinating mechanism. Additionally, it permits the involvement by the public in an appropriate manner.

A second suggestion that appeared to have general concurrence was the establishment, ahead of time, of a plan of action which would be detailed but would be sufficiently flexible that it could be used in the event of any such emergency. Reference was made at the inquiry to Amoco's emergency response plan and to the plan of ADS discussed above. The Panel understands the ADS plan incorporates the most recent views of the various Government departments and agencies.

The Panel believes the emergency plan should be reviewed and consideration be given in the review to the recommendations in this report.

9.6 Summary of the Panel's Views

Despite efforts by involved parties, particularly Amoco and AE, the Panel concludes that communication with the public was not effective during the Lodgepole blowout. A plan is needed which would ensure that an efficient two-way communication program would be quickly put into action in the event of any future emergency.

Co-ordination among Government departments and agencies was reasonably efficient but was not always perceived as such by the public. A plan clearly setting out responsibilities should be prepared so that the departments and agencies clearly know when and how to act and so that the public are aware that co-ordination is effective.

9.7 Recommendations

The Panel recommends that:

1 A model communication program, along the lines suggested in section 9.4, be developed by appropriate Government departments and agencies with input from the public and industry.

2 The "Peacetime Emergency Operations Plan For a Sour Gas Release", recently issued by ADS, be reviewed in light of the Panel's recommendations.

3 The establishment of a "command post" organizational structure be confirmed and implemented for all significant blowouts.

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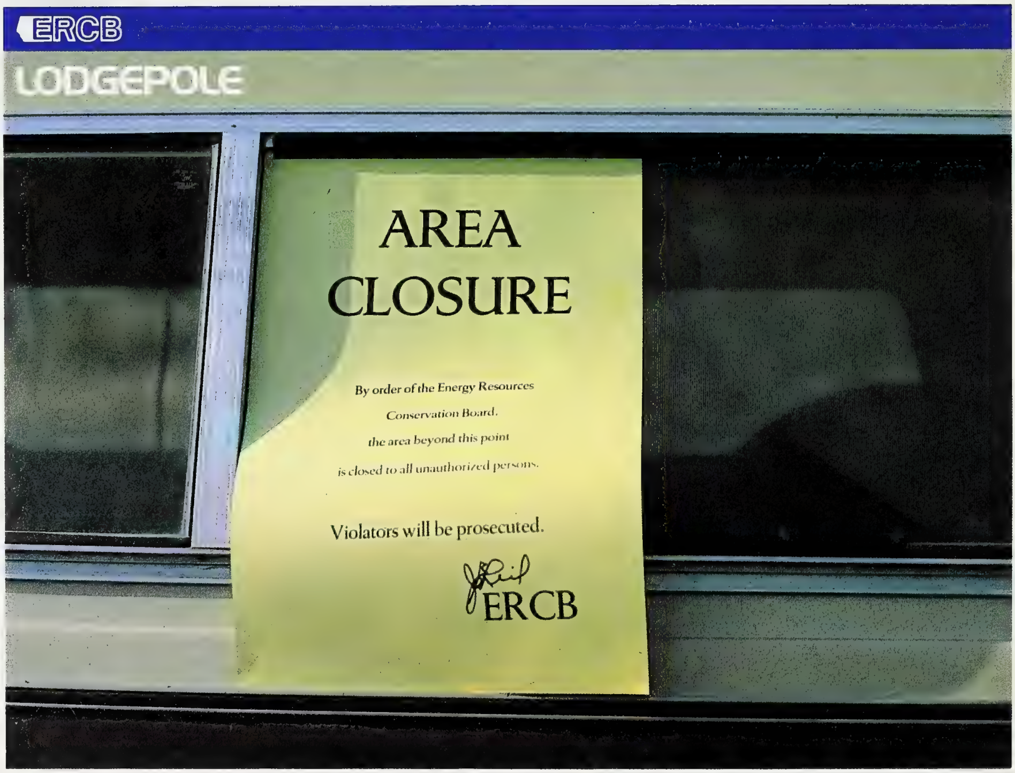


AREA
CLOSURE

By order of the Energy Resources
Conservation Board,
the area beyond this point
is closed to all unauthorized persons.

Violators will be prosecuted.

ERCB

Posted-area signs used to alert the public.

Photo credit: W. Wylie, ERCB

10 ADEQUACY OF ERCB RESPONSES FOLLOWING THE BLOWOUT, AND ITS REGULATIONS, POLICY, AND PROCEDURE

10.1 Introduction

This section of the report is intended to assess the role which the ERCB played in the blowout of the 13-12 well. It deals with the response of the ERCB to the blowout and evaluates whether it was consistent with the then existing regulations and policies. Of even greater importance, it also comments on the adequacy of those regulations and policies and recommends changes on the basis of the experiences at the 13-12 well.

The adequacy of the ERCB's involvement is discussed for each of the following three aspects of the blowout:

(a) drilling operations,

(b) operations to regain control, and

(c) impact on the public.

10.2 Drilling Operations

10.2.1 Well Licensing Requirements

The 13-12 well was licensed on 10 August 1982. All requirements then existing for licensing were satisfied and the procedures used by the ERCB were consistent with those used in licensing many thousands of wells during the same general time period.

Policies then in use by the ERCB did not routinely attach special conditions to the licences of wells which might encounter substantial volumes of H_2S and none were attached to the licence for the 13-12 well. It did require an estimate by Amoco of the maximum potential release rate. Because of the estimated relatively low H_2S release rate and the relative remoteness of the well from population centres, the existing ERCB policy did not require a site-specific emergency response plan. One possible deficiency in ERCB staff procedure was that it apparently accepted an estimated maximum potential H_2S release rate from Amoco without adequately checking its validity. Evidence indicated that the original estimate was substantially less than the actual flow rate.

While the licensing procedures were consistent with then existing requirements and policies, the experiences gained as a result of the blowout and the subsequent inquiry have satisfied the Panel that the regulations and policies did not adequately recognize the critical nature of the operation given the high volume of H_2S which could be released if a sour gas blowout were to occur. As indicated in its Phase 2 report, the Panel believes there is a need for special licensing requirements for certain critical sour wells. These requirements include:

(a) a site-specific emergency response plan which satisfies the ERCB that, in the event of a blowout, the public would be adequately protected. The plan should be based on a realistic H_2S release rate and an improved method is needed for calculating the maximum potential release rate prior to the licensing of a critical well,

(b) the ERCB should require a general description of the drilling plan and satisfy itself prior to the issuance of a licence that the equipment, mud system, and other drilling details are satisfactory, and that possible over or underpressured zones and other problems are provided for,

(c) the ERCB should be satisfied with the qualifications and experience of the drilling supervisors. During critical periods, no supervisor should be responsible for key decisions for a period longer than 12 consecutive hours,

(d) service personnel and drilling crews should have appropriate experience and be adequate in number,

(e) properly qualified safety personnel and up-to-date safety equipment should be on the site during critical operations,

(f) the BOP equipment should be inspected in detail by the ERCB prior to critical operations, and questions such as the need for shear rams, the proposed location of the master control panel, and the correct configuration of the BOP stack should be addressed, and

(g) intermediate casing should normally be set above the critical zone.

10.2.2 Rig Inspections

The Nabors rig was inspected by ERCB staff on the 13-12 well site on 18 August 1982. The inspection was in accordance with established policies and the rig was found to be satisfactory. The Panel is satisfied in this regard but believes that critical wells should have a greater than normal inspection frequency and that the inspections should be very detailed. These should be conducted both by staff of the operating company and the ERCB and should be fully documented. In particular, a thorough inspection should take place just prior to commencement of drilling in the critical zone. This matter is discussed in the Phase 2 report.

10.2.3 Drilling Operations in the Critical Zone

At the time the 13-12 well was drilled, there were no special ERCB regulations or requirements respecting drilling operations in the critical zone. It thus follows that there was no contravention of the regulations in this regard. However, having in mind the circumstances which led to the blowout, as described in detail in section 5, the Panel believes the ERCB should give consideration to the need for special requirements to apply to critical sour wells. The requirements to be considered should emphasize the need for particularly cautious and safe practices to be applied at all times when drilling in the critical zone at such wells. They would be in addition to the increased and thorough inspections referred to in the above section.

The type of requirements that the Panel believes the ERCB should give consideration to are as follows:

(a) the need for more detailed documentation respecting checks of the mud system and other key equipment, and counter-signing of such reports by the senior supervisors for both the oil company and the drilling contractor,

(b) the need for more detailed documentation of blowout prevention and safety drills to ensure that such drills are carried out regularly and in an effective manner,

(c) the possibility of increased contacts with the field offices of the ERCB and of an increased role for the ERCB staff, and

(d) the possible need for stronger action by the ERCB when regulations are not strictly adhered to.

The Panel recognizes that the above type of increased control might be difficult to implement on a province-wide basis and would require increased staff on the part of the ERCB. It believes, however, that the potential impacts of a blowout at certain critical sour wells is so great that rather extreme measures must at least be considered.

10.3 Operations to Regain Control

10.3.1 Immediately Following the Blowout

The ERCB was informed of the 13-12 blowout within 2 hours of its occurrence and immediately informed the appropriate Government departments. It took steps to ensure that the site was secured from the public and that initial activities of Government departments were properly co-ordinated.

Although the actions of the ERCB were largely adequate during the initial period, the "one-window" process would have been more effective if a plan had been in place ahead of time which specifically set out responsibilities of the Government departments and identified those to be contacted. Additionally, a more realistic estimate of H_2S concentrations and gas flow rate at the outset would have allowed a better-informed assessment of the safety risks to the public involved, and the best follow-up actions respecting well control, air monitoring, and the need for more immediate actions by public health agencies and other Government departments. The problem of estimating emission rates is addressed in the Phase 2 report, and the current requirements are identified in a Draft Interim Directive issued concurrently with the Phase 2 report and included in it as an appendix.

10.3.2 Well Control Alternatives

10.3.2.1 Consideration of Major Options

The ERCB was aware of and concurred with on-going decisions by Amoco not to intentionally ignite the well and/or not to proceed with the actual drilling of a relief well, although a drilling site was prepared and a rig was placed on standby.

The Panel is generally satisfied that those decisions were reasonable, particularly during the initial period and given the general view that top-hole control of the well consistently seemed to be only a few days away. However, it believes that the ERCB's involvement in these decisions should have been clearer and more formalized. Additionally, the reasons for the decision should have been documented and made known to the public. As the duration of the blowout became more extended, increased consideration should have been given to the other alternatives, particularly igniting the well. The on-going impact of the H_2S emissions on the public while the well was not burning should have been a major consideration in making the decisions not to ignite the well. It is not certain from the evidence that this was the case, and a system should be devised to ensure that it would be in the event of future similar occurrences.

10.3.2.2 Alternative Top-Hole Control Plans

A series of plans for top-hole control of the well was developed and utilized by Amoco. The ERCB was continuously aware of these plans and gave its on-going "approval" to them. The Panel believes that this aspect of the ERCB's involvement was reasonable. However, in future instances, the ERCB should be more actively involved and its decisions on proposed actions more formalized and better documented. This would ensure that accurate, up-to-date information respecting well-control operations could be made available to the public.

10.3.3 Co-ordination Among Government Departments and Agencies

The ERCB played the major role in co-ordinating on-site activities insofar as government involvement was concerned. This appeared to be carried out effectively. The matter of workers' safety was handled independently by OH&S. The Panel sees nothing wrong with that approach, but believes that an overall emergency control plan is needed which clearly spells out the responsibilities of the various Government departments and agencies.

10.3.4 Environmental Impacts

These matters relate to control operations in that the period over which they occur and the type of pollutants can be affected in a major way by decisions respecting well control. For example, the ignition of the 13-12 well would have changed the major air pollutant from H_2S to SO_2 and would have eliminated most of the condensate which was being deposited near the well.

The ERCB co-ordinated efforts with AE and AFS to ensure that containment dikes for condensate were constructed. These efforts were reasonably successful and the Panel is satisfied that the ERCB's co-ordinating functions were useful.

10.4 Effect on the Public

10.4.1 Health Standards and Evacuation Policy

These matters are discussed in detail in section 7, but because of their importance, they are reviewed here in terms of the adequacy of ERCB's involvement. In doing so, it should be noted that the ERCB does not have legislative responsibility for these matters.

The Panel believes there is a strong need for a clear statement of health standards so that in future, the ERCB, which is usually the first government organization involved, can initiate actions to protect the public during the first hours of a blowout and to ensure that public health officials are fully informed respecting well emissions.

10.4.2 Monitoring of Emissions

Monitoring is discussed in section 7 and again, the ERCB does not have direct responsibility. Nevertheless, there is an additional need for the licensee of a well to have a site-specific emergency response plan to be in place so that the ERCB can ensure that the matter of emission monitoring is initiated promptly.

10.4.3 Communications With the Public

This matter is dealt with in section 9 of the report. As indicated there, the Panel believes that this area was not adequately handled during the 13-12 episode by all parties, including the ERCB. There is a need to formulate a communications plan of action which could be implemented during serious blowout episodes and which would inform the public as to what is taking place at the site, existing health standards, the monitoring program, and essentially all aspects of the incident.

10.4.4 Co-ordination of Activities of Government Departments

As indicated previously in section 9 of the report, co-ordination of most aspects of the 13-12 blowout was reasonably handled. However, there were a number of matters where confusion was apparent at least to the public, and where conflicting decisions could have been made. The Panel believes an overall response plan is needed which clearly spells out responsibilities of the Government departments and agencies and ensures maximum co-ordination of all activities.

10.5 Summary of Panel's Views

The Panel is satisfied that the actions of the ERCB prior to, during, and following the blowout were in accordance with the existing regulations and policies. It further believes that most of the regulations and policies are adequate for the large majority of wells drilled in Alberta, but is concerned that they do not adequately recognize the potential consequences of a blowout at a limited number of "critical" sour wells which require extra precautions prior to licensing. These precautions would relate to:

(a) the detailed drilling program,

(b) drilling and blowout prevention,

(c) training and experience of the supervisors and crew,

(d) availability of safety equipment and personnel,

(e) frequency and detail of inspections, and

(f) possible need for special reporting and other requirements while drilling in the critical zone, and for stronger action by the ERCB when such regulations are not strictly adhered to.

There is also a need for a site-specific emergency response plan detailing, among other things, means of communicating with the public in the event of a blowout.

The role of the ERCB with respect to co-ordinating on-site activities with other Government departments and agencies was fully adequate. However, communications with residents in the area and the general public was not at all adequate. In addition to the site-specific plan, efforts are necessary to clearly establish responsibilities of various Government departments and agencies in emergency situations such as the 13-12 blowout. A communications plan is also needed.

10.6 Recommendations

The Panel makes the following recommendations, all of which relate to the role of the ERCB in dealing with blowouts.

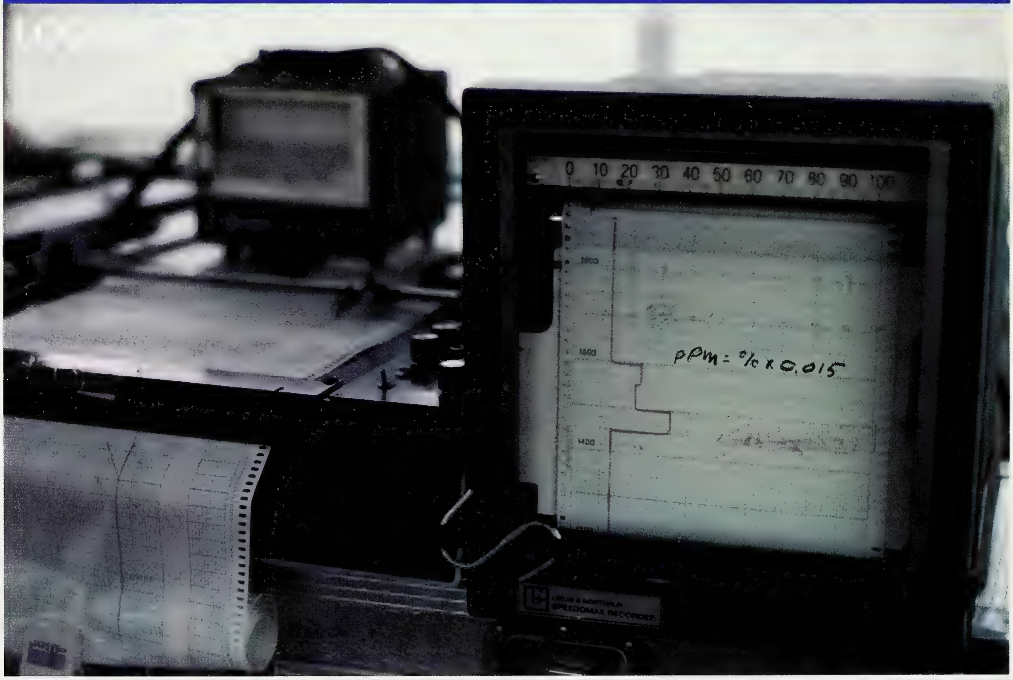
1 The ERCB, with appropriate input from industry, the public, and other Government departments, should define wells which are "critical" in terms of avoiding possible blowouts and establish special conditions that must be satisfied by an operator before these wells can be drilled. The ERCB should advise other Government agencies of all licences issued for critical wells.

2 The ERCB and other involved Government departments should establish a plan for their involvement in future emergencies such as the 13-12 well. The plan should include, among other matters, details regarding the responsibilities of various parties, standards for notification and evacuation, and plans for communication with the public and the media. Care should be taken that appropriate municipal officials are aware of the plan.

3 Special efforts should be made to more accurately estimate the potential H_2S release rate for a critical sour well.

The recommendations have already been totally or partially implemented, as a result of the Phase 2 report.

ERCB



Typical air monitor and print-out equipment.

Photo courtesy Alberta Environment

11 ADEQUACY OF THE GOVERNMENT DEPARTMENTS' RESPONSES FOLLOWING THE BLOWOUT, AND THEIR REGULATIONS, POLICY, AND PROCEDURE

11.1 Introduction

This section deals with the responses by the various Government departments to the blowout at the 13-12 well and assesses whether existing regulations, policy, and procedure were adequate to handle the situation. As was the case in dealing with the ERCB responses in section 10, the Panel will address the following three areas:

(a) drilling operations,
(b) operations to regain control, and
(c) impact on the public.

11.2 Drilling Operations

The involvement of Government departments before or during drilling operations at the 13-12 well was minimal. AFS granted a surface lease to Amoco in February 1982 to drill the 13-12 well. The surface location of the well had been moved away from the Pembina River at the direction of AFS due to environmental concerns. The move of the surface location and Amoco's interpretation of the subsurface geology necessitated the directional drilling of the hole, but given the blowout that occurred, it was fortunate that the surface location was not as originally intended.

The regulation of workers' health and safety during drilling operations was the responsibility of OH&S, who placed the onus on Amoco for the health and safety of both their employees and their contractors. There is no evidence that regulations pertaining to workers' safety were seriously inadequate for normal drilling operations or that they were not adhered to. One exception relates to the number of breathing apparatuses which must be kept at a rig site. The Panel believes the existing regulation, even though it was amended 1 September 1984, may not be adequate and that appropriate masks should be available for each worker on the site and not just the operating crew.

Enforcement of regulations of the various Government departments results in only limited visits to drill sites. The Panel believes that critical sour wells should be inspected more frequently than other wells, not only by the ERCB, but by other Government departments. This is because accidents to workers or the existence of faulty boilers or electrical systems could lead to a blowout or complicate actions to control one in the early stages. For the same reason, workers' safety requirements for sour gas wells should be more stringent than for wells in general.

The Panel believes that OH&S should undertake a review of these matters and should involve other Government departments, the industry, and the public. The Panel believes that some aspects of the review might be effectively accomplished by a series of workshops.

11.3 Operations to Regain Control

Co-ordination of most on-site matters of relevance to Government departments was handled by the ERCB. No serious deficiencies existed in this regard. Necessary approvals for tree clearing, road construction, and stream crossings were handled expeditiously and in a responsible manner by AFS.

Several Government departments were interested in and apparently somewhat involved respecting the decisions not to intentionally ignite the well or to proceed with a relief well. As mentioned previously in this report, the Panel believes the ERCB's role in this matter might have been more formalized. It also believes the involvement of other Government departments should have been better co-ordinated. For example, the changing status of ground-level H_2S concentrations in the area and the number of telephone complaints were not systematically communicated to the appropriate agencies and departments.

OH&S was aware of the blowout within a day of its occurrence and had continued involvement throughout the episode, but its highly qualified occupational health staff were not brought to bear until after the accident involving fatalities a month later. Although evidence suggests that its role was more responsive than pro-active, it was somewhat aware, through its safety inspector, of the safety equipment and procedures being used and was involved in planning meetings. Prior to the accident, OH&S allowed Amoco to use the demand type respirators (non-positive pressure), and subsequently ordered the use of pressure demand masks (positive pressure). The Panel believes that OH&S should reconsider its position and perhaps play a more pro-active role when serious emergency situations such as the 13-12 blowout exist. In such instances, OH&S should consider the advisability of assigning a senior specialist on a qualified full-time basis to the control operations phase to ensure that the safety equipment and procedures are fully adequate.

Securing the blowout site against access by the public was effectively carried out, although there were apparently one or two minor problems likely caused by insufficient co-ordination and communication among involved parties.

AFS took action throughout the blowout to ensure that trees were removed in the immediate area of the well site so that the fire hazard would be lessened. Additionally, AFS and AE, along with the ERCB, required actions to minimize environmental impact. All of these activities were reasonably successful.

The Panel's review of the actions of various Government departments during the well-control phase reveals a number of matters where roles and responsibilities may not have been clear. The Panel believes that an overall plan is required which, among other things, should clearly spell out the responsibilities of Government departments and agencies.

11.4 Effect on the Public

11.4.1 Standards and Evacuation

ADS, AE, SS&CH, the PBOH, along with the ERCB and Amoco, all played a role in setting or interpreting standards, notifying residents in the area, and establishing evacuation criteria. Although each of these groups had the interest of the public in mind and took actions which they considered appropriate, there appeared to be lack of an effective co-ordination system and a lack of systematic communication with the public. These short-comings contributed substantially to the concerns and anxieties of the public.

The Panel is satisfied that the actions taken in the 13-12 incident were generally adequate, although not necessarily well co-ordinated, and that, except for very sensitive individuals, residents were not left in unacceptably hazardous situations due to lack of action by Government departments or others. The situation with respect to very sensitive people is not clear, and as indicated in section 7 the Panel believes that appropriate standards need to be developed. The Lodgepole experience should assist in that endeavour. There is a need for a clear statement, prior to the time of an emergency, respecting appropriate standards and evacuation criteria. These should be part of an overall emergency plan and also should be addressed in site-specific emergency response plans for critical sour wells.

The overall plans should also put in place a system to provide individuals, doctors, and hospitals with assistance and advice respecting the standards.

11.4.2 Monitoring

AE played a lead role in terms of monitoring of the general area to determine ambient concentration levels of H_2S and SO_2. As indicated in section 7, the Panel is generally satisfied that the monitoring was adequate. With respect to the role of AE, it believes co-ordination of the monitoring might have been improved if a control centre had been set up, probably in Drayton Valley, to receive complaints and to dispatch the units. Also, although AE was commended by many local residents for its helpful attitude, the results of monitoring should have been made more readily available to all residents of the area.

AE made several recommendations which related to monitoring. One is that it be given full control of off-site monitoring along with responsibilities to ensure it is adequately carried out. Another is that all available information which might assist in estimating the H_2S release rate be provided to AE at the outset of any sour gas blowout. The Panel believes both of these recommendations are sound and recommends that they be embodied in on-going plans for handling sour gas emergencies.

AE also recommended a review of industry's capability to do extensive monitoring in the event of serious mishaps. The Panel believes that knowledge of this nature on an on-going basis would assist in planning and suggests that the ERCB and AE jointly make such a review.

11.4.3 Communication

As is noted in section 9, which deals with communication in some detail, there was a general inadequacy in this respect. This was true of the Government departments as well as other involved parties.

There was general agreement among the participants during the inquiry that better planning, co-ordination, and communication were necessary and, indeed, one of the recommendations of AE dealt specifically with improved communication with the public. The Panel agrees that this is a very important aspect of dealing with the public and believes a general communication plan is necessary in the event of future emergencies.

11.4.4 Co-ordination

In dealing with the public, co-ordination among Government departments was not well organized. SS&CH is responsible for determining possible health effects. Its process of accessing information from AE, the ERCB, and others, and initiating appropriate action, including advice to the public, was less than adequate. There was no single government telephone number which could be reached and where one would be given a clear statement regarding health standards, monitoring results, or other matters which the Government departments had responsibilities for. Partly as a result, many of the public relied on information from various sources including the media, visits to medical doctors, over-the-fence personal discussions, or casual comments on the street. This situation contributed to the level of concern and anxiety on the part of the public and to some extent may have been alleviated if government authorities had been better co-ordinated and taken a more prominent role in providing information to the public.

This matter must be addressed in a government emergency response plan.

11.4.5 Data Collection and Research Program

There were suggestions at the inquiry that protocols be put in place so that if a similar situation develops in future, data could be gathered from the outset and research could be conducted to increase the knowledge of impacts of H_2S and SO_2 on humans. SS&CH commissioned Dr. Love to assess the feasibility of site-specific work towards this objective following the blowout, but he determined that a meaningful study was not feasible.

Several participants recommended that the government initiate research into the effect on health of exposure to long-term low-level H_2S concentrations. The Panel defines “long-term” to be a period of about a week or longer. The Lodgepole incident demonstrated that concentrations as low as 0.1 ppm for relatively short durations can apparently result in reactions by sensitive persons. The Panel understands that the Alberta Environmental Centre has been pursuing a major research effort in this area for the last 3 years. The PBOH proposed other research into the health effects of long-term low-level exposure to H_2S, but it was decided to wait until the inquiry had been held. As set out in the section 7 recommendations, the Panel believes the possibility of this research should be considered.

AE recommended that steps be taken to determine the detailed composition of all gases which could be emitted from oil and gas pools in the province. The Panel believes there is a need to understand more fully the composition of potential emissions and recommends that the ERCB initiate a study of the matter.

During the period of the blowout, AA visited the area, responded to questions from the public, and had on-going communications with District Agriculturists and veterinarians in the area. On-going research is also taking place. All of these actions were useful and the Panel endorses them. However, it believes they would be more effective if AA took a more pro-active role and publicized to a greater extent its availability to advise and assist the rural population. Plans should be put in place now, so that agricultural information can be readily obtained and evaluated in the event of future emergencies.

11.5 Summary of Panel’s Views

The involvement of Government departments following the blowout of the 13-12 well was not altogether adequate. This may have been as a result of a failure to recognize at an early date the seriousness of the situation and to alter their approach accordingly. This was an apparent problem for the ERCB and Amoco as well.

Co-ordination respecting on-site matters during the blowout was good and the orders and approvals necessary to secure the site and proceed with capping operations were given in an efficient manner. The Government departments’ role respecting environmental matters was adequate, however, responsibilities of the various departments should be clearly spelled out.

Worker-safety problems developed during control operations and there is a need for more effective planning for the handling of such matters for critical sour wells. This might be assisted through a series of safety workshops organized by OH&S, and by appropriately trained personnel properly conducting inspections.

During the blowout, several Government departments were reviewing and assessing possible public health consequences through interdepartmental committees but did not take public action because they believed that the concentration of pollutants being experienced by most people were not injurious. The Panel believes they underestimated certain effects as described in section 7.2.1. This may account for a lack of communication with the public on these matters and this led to confusion and concern. The matter of handling human health concerns, including evacuation criteria, is an important topic that must be addressed in an overall plan for the handling of sour gas releases.

11.6 Recommendations

The Panel makes the following recommendations respecting the role of Government departments in sour gas blowouts.

1 A government emergency response plan should be put in place for dealing with sour gas releases in the province. Such a plan has been prepared by ADS on an interim basis and will be reviewed in light of this report, comments from the public, and other involved parties. It should be maintained on a current basis. The final plan should address all significant matters relevant to serious sour gas releases and in particular the following:

   (a) the responsibilities and authorities of various departments and agencies,

   (b) the need for a control and communication centre,

   (c) procedures to obtain the best possible estimates of gas flow and composition data,

   (d) the availability of suitable equipment for monitoring,

   (e) ways in which to make communications with the public and media more effective,

   (f) standards, notification, and evacuation criteria and procedures,

(g) the decision process with respect to possible ignition of wild wells,

(h) the collection of data for health research purposes, and

(i) impact of sour gas on animals and crops and ways of better advising rural people respecting these matters.

The public should have the opportunity for input to the plan and should be made aware of its existence when it is in place.

2 OH&S should review its procedures and regulations respecting the suitability and number of breathing apparatuses, the training of workers in their use, review procedures for dealing with workers' health and safety matters for sour wells, and develop a program of direct involvement by senior OH&S staff to be implemented in the event of a blowout. This might be done through a series of workshops.

3 The PBOH should review existing H_2S exposure standards, particularly as they relate to sensitive individuals, in light of experience gained from the Lodgepole blowout.

12

Lodgepole Inquiry Panel members.

Photo credit: G. Brosinsky, ERCB

12 FINDINGS AND RECOMMENDATIONS

12.1 Introduction

In the foregoing sections, the Panel has considered the major issues identified in the inquiry's terms of reference. The purpose of this section is to summarize the Panel's findings and to provide a consolidation of the recommendations contained in each of the sections.

12.2 The Cause of the Blowout and the Adequacy of Amoco's Actions

12.2.1 Findings

1 The 13-12 well blew out of control on 17 October 1982 because a series of kicks occurred during coring operations and were not controlled.

2 The kicks occurred primarily because drilling practices during the taking of cores No. 2 and 3 were deficient and, when combined with the marginal density of the drilling mud, permitted the entry of reservoir fluids into the wellbore.

3 The kicks were not controlled because:

- (a) the drilling crew did not immediately recognize the problem and did not immediately carry out prescribed kick-control procedures,
- (b) several pieces of vital equipment either did not function properly or were not completely operational, including:
  - (i) the degasser,
  - (ii) casing pressure instruments,
  - (iii) travelling block hook and latch, and
  - (iv) drill pipe, and
- (c) sufficient mixed and conditioned mud was not available during kick-control procedures.

4 Amoco applied reasonable judgement in approving the degasser installed on the Nabors rig, and to a lesser extent, in selecting the type of drill pipe to drill the well, even though with hindsight each turned out to be an unfortunate choice.

5 Amoco's actions were not satisfactory with respect to:

- (a) drilling practices during coring operations (cores No. 2 and 3),
- (b) prompt implementation of standard kick-control procedures,
- (c) ensuring adequate drilling mud was available at all times, and
- (d) maintaining equipment in satisfactory condition (casing pressure instruments and possibly mud volume indicators).

6 Drilling operations should always be conducted with caution, with full awareness of potential events, and a preparedness to meet unexpected problems. That requirement is particularly important for wells which may encounter sour gas and especially while drilling in critical zones.

7 Amoco's drilling operations in the critical zone did not display the necessary degree of caution. Moreover, when unexpected problems developed, the company was not fully prepared to meet them. Having regard for its previous blowout at the nearby 7-10 well, just 5 years earlier, the Panel would have expected that Amoco would have applied extreme caution in planning and drilling the 13-12 well.

8 The major deficiencies identified in the 13-12 blowout relate to the "human factor" that received so much attention at the Phase 2 hearing.

12.2.2 Recommendations

1 The following types of equipment should be examined for design, capacity, and operational problems to ensure that they are adequate for worst-case conditions:

- (a) degasser,
- (b) casing pressure instruments,
- (c) travelling block hook latch,
- (d) kelly hose,
- (e) blowout preventers, and
- (f) equipment for anchoring drill pipe.

2 The BPRC should examine the impact of H_2S, and how to avoid those impacts on:

- (a) drill pipe,
- (b) external BOP components, and
- (c) BOP master controls.

3 The industry and ERCB should take any action necessary to ensure that drilling operations are carried out in a cautious manner, particularly in the critical zone of critical sour wells. Special procedures should be developed, documented, and used for operations in the critical zone. These would include detailed instructions respecting tripping in, tripping out, coring, testing, and other operations where particular care is required.

4 Standard kick-control procedures should be reviewed to determine whether they allow for situations where equipment failures or other unexpected events occur during control operations.

5 The adequacy of the current training programs for drilling personnel should be reviewed and, in particular, consideration should be given to ensuring

that they are effective in ensuring crew familiarity with kick recognition and control.

6 Consideration should be given to the need to have special expertise available while operations are being conducted in the critical zone of critical sour wells.

7 The ERCB should review its inspection system and, in particular, it should conduct special inspections of critical sour wells immediately prior to entry of the critical zone and while drilling in it, to ensure that operations are being conducted in a cautious manner and consistent with proper procedures.

8 Mud system design and operation should be reviewed respecting density, system capacity, back-up supply, scavengers, and impact of H_2S on mud and the ability to pretreat and recondition it.

9 OH&S should consider amending its regulations to ensure that breathing apparatuses are available for all individuals that may be at a rig, including extra people called in for an emergency.

12.3 Well-Control Activities and the Adequacy of Actions by Amoco and Others

12.3.1 Findings

1 Amoco's general emergency response plan was satisfactory for well-control operations because it brought together those persons who had knowledge and authority to implement necessary actions.

2 With the exception of well control Plan A, which did not have significant impact, the well-control plans proposed by Amoco, and approved by the ERCB, were satisfactory even though actual events proved several of them to be unsuccessful.

3 Regaining control of the well required 67 days because

(a) the well had a particularly high flow rate and high H_2S and condensate content,

(b) weather conditions were frequently unfavourable and prevented work on the well for more than 10 days, when the control plan in effect at that time was based on capping the well when it was not on fire,

(c) the normal industry safety procedures and equipment proved insufficient to cope with the magnitude and type of emissions from the well, and

(d) the final and successful control plan for capping the well while on fire required 21 days for preparation of the site and equipment, and because of delay due to weather conditions before it could be completed.

4 The decision by Amoco and the ERCB not to drill a relief well, as a means of regaining control of the 13-12 well, was reasonable.

5 The decision by Amoco and the ERCB, during the initial period, not to try and cap the well while on fire (even though this was the final and successful plan) was reasonable at the time, having regard for the expectations of successfully capping the well while not on fire and the serious risks inherent in an "on-fire" control process.

6 Decisions on well-control plan options were deficient in that they did not adequately take into account the effects the emissions were having on the public, or the seriousness of the public's concerns.

7 Amoco's actions, except for the relatively minor problem of the pipe stripper respecting control Plan A, were adequate with respect to regaining control of the well. Amoco applied diligence, technical expertise, and all the necessary resources for regaining control as quickly as possible.

8 The ERCB applied diligence and technical expertise regarding control of the well. However, it did not adequately take into account the impacts on, and concerns of, the public in reviewing the suitability of the various control operations proposed by Amoco.

9 OH&S was not sufficiently involved in the safety procedures during the initial well-capping operations.

10 Safety measures were not successful on 16 November during attempts to cap the well while it was not on fire and the deaths of two workers occurred. Safety procedures to be used in emergency situations require review.

12.3.2 Recommendations

1 The ERCB and the involved operator should make a serious effort at the outset of any blowout to ensure that the flow rate and other characteristics are estimated as accurately as possible, and that the estimates and the expected weather conditions are properly recognized in planning for control of the well.

2 The ERCB should formalize, to a greater extent, its involvement in decisions related to intentionally igniting blowouts and the possible drilling of relief wells. A process should be developed that would ensure that public concerns are properly considered in making these decisions, and the reasons for the decisions are communicated to the public.

3 OH&S should give consideration to the establishment of a committee to be concerned with protect-

ing workers in toxic gas environments such as would result from episodes like the 13-12 blowout. Such a committee might be composed of experts on safety and rescue drawn from OH&S, the petroleum industry, the ERCB, and the Calgary and Edmonton fire departments. These individuals, or a team which they could assemble, could be readily available to act as advisers or participants in the management of the safety aspects of particularly dangerous situations in the petroleum industry. With respect to the prevention of serious accidents, they could assist in reviewing current and future safety and rescue practices and safety educational programs.

4 OH&S should give consideration to the development of an adequate, possibly compulsory, training program for workers who might encounter H_2S or other toxic gases in substantial amounts. This training would be needed prior to their involvement at a well site or other potentially dangerous locations. This training should emphasize practical matters such as familiarization with and the wearing of a self-contained breathing apparatus. Through such a program, workers who are physically or psychologically unsuitable for work in such hazardous environments, or while wearing masks, would likely be identified.

5 The ERCB should investigate the availability and limitations of blowout insurance. The Panel understands that the matter of insurance is being looked at by the ERCB as a result of the Phase 2 report.

6 The ERCB should consider how the experience and expertise needed to control a blowout would always be available when required, even by a small organization.

7 OH&S should pursue the development of clearly distinguishable names for all types of masks to be used in the presence of various concentrations of H_2S.

8 Consideration should be given by industry and the ERCB to the development of a workshop or seminar to consider technical matters related to the control of wild wells.

12.4 Hazard to Human Health

12.4.1 Findings

1 While there was no scientific basis for the Panel to make any definitive conclusions regarding effects of well emissions on human health, it is satisfied that a substantial number of people experienced at least short-term health effects such as headache, eye irritation, upper respiratory tract symptoms (sore throat, nasal irritation, and nosebleeds in children), and lower respiratory tract symptoms (pain on deep inhalation and some shortness of breath). Persons with respiratory problems appeared to be especially affected. Several of the PASGEC witnesses referred to similar symptoms of illness in both people and livestock.

2 Government departments and the ERCB established and applied a set of H_2S exposure limits that were designed to protect human health.

3 The H_2S exposure limits, established for persons more susceptible to the emissions, were generally criticized by the public as being inadequate.

4 Anecdotal evidence raises questions about the H_2S exposure limit, particularly for sensitive persons.

5 Under the direction of AE, H_2S concentrations downwind from the well were monitored by a combination of mobile and stationary monitors to ensure that if concentrations exceeded the exposure limits, the residents would be advised to vacate the area.

6 On six occasions, when H_2S concentrations near residences reached 15 ppm, residents temporarily left the area. Additionally, Amoco offered assistance to residents to leave the area if the emissions were causing problems, and 28 individuals plus 4 families moved temporarily on that basis.

7 During the 26 days that the well was not on fire, H_2S concentrations at, or near, residences exceeded 10 ppm for about 31 hours in total, and 5 ppm for 61 hours. The stationary monitors located at Lodgepole, Cynthia, and Drayton Valley recorded concentrations less than 1 ppm for 87, 95, and 96 per cent, respectively, of the total hours monitored. In Edmonton, the maximum concentration recorded was 0.5 ppm, and the overall concentrations were about one-tenth of those experienced by the three communities near the well.

8 On 23 November, H_2S concentrations at Cynthia approached the evacuation limit and residents were advised to be prepared to leave. The concentrations subsequently declined and the evacuation alert was cancelled. That incident created considerable controversy and some participants questioned whether the standards had been followed. After careful examination of the actual monitoring data, the Panel found that the standards had been followed.

9 The Panel is satisfied that the air monitoring program was comprehensive and, with the exception of sensitive persons residing in rural areas, provided

sufficient information to apply the established exposure limits. The exception was due to the special standard for sensitive persons, which relied on a lower level of exposure for 5 to 6 hours. Since concentrations in the rural areas were monitored by mobile units, it was not possible to determine whether that exposure limit had been satisfied.

10 While the monitoring was effective, the communication of the plan and its results to the local people was quite inadequate. Residents were not advised about the program, and were not always able to obtain answers to their inquiries about monitoring results.

11 While the well was on fire, the H_2S was converted to SO_2. Because of the intense fire, the emission plume had substantial rise, and its dispersion was effective. Throughout the blowout period, SO_2 concentrations were substantially below the related ambient air quality standards.

12.4.2 Recommendations

1 The PBOH should reconsider its H_2S exposure limits in light of the Lodgepole evidence and, in particular, for “sensitive individuals”.

2 Information should be obtained by the PBOH on the biological effects of extended intermittent and continuous exposure to moderate and low-level concentrations of H_2S, such as were experienced by residents and animals during the Lodgepole blowout. This could be obtained by modern research techniques.

3 AE, the ERCB, and representatives from industry and the public should develop a comprehensive centrally dispatched air monitoring plan that could be implemented immediately when needed.

4 AE and the ERCB should arrange for a comparison and analysis of actual H_2S concentrations obtained by monitors and the predicted concentrations from dispersion modelling, with the objective of improving the latter capability.

5 Further consideration should be given by the PBOH and other medical bodies to whether useful information could be obtained from a review of actual medical experience during the blowout, and to consider whether better measures can be implemented to determine the effects of emissions from other blowouts which may occur in the future.

6 Methods of providing remote rural residents with Drager units and possibly crush ampoules, and training in their use, should be addressed in site-specific emergency response plans.

7 The ERCB should attempt to identify all of the gaseous contaminants, in addition to H_2S and SO_2, which could be produced by a sour gas well, since other components could also have biological significance. This type of physical chemical analysis could be carried out on material safely obtained from an existing well or wells.

12.5 Impact on the Environment

12.5.1 Findings

1 During the 67 days the well was out of control, there was a daily emission of 150 to 450 tonnes of sulphur and 300 to 1100 m^3 of condensate. For the 26 days the well was not on fire, the condensate fell on the area immediately surrounding the well site and had an impact similar to an oil spill. When the well was ignited, the condensate was combusted in the extremely intense fire, and the H_2S was converted to SO_2.

2 In the area of some 300 ha immediately surrounding the well, the emissions had major impacts on vegetation and soils, and minor impacts on surface water, groundwater, benthic organisms, mammals, and birds.

3 A program of remedial measures was quickly implemented to minimize these environmental impacts.

4 There is no evidence that the sulphur deposited on the ground in low concentrations, over an area of hundreds to thousands of square kilometres, will have any long-term harmful effects on the soils, vegetation, or bodies of water.

12.5.2 Recommendations

1 AE and other appropriate Government departments should establish a protocol for improved sampling and analysis of soil and vegetation that would provide a means of evaluating impacts of sour gas releases on soils and vegetation if a blowout occurs in future.

2 AFS should co-ordinate long-term monitoring of impacts on the biosphere in the “on-site and immediate” area of the 13-12 well, plus adjoining areas of the blowout, as defined in this report.

3 AA should develop a protocol to enable the gathering of timely and relevant data on agricultural activities if another serious sour gas release occurs.

4 AA should consider conducting an on-going examination of livestock in the general blowout area to determine if effects of long-term exposure to H_2S can be found.

5 The ERCB, the industry, and appropriate Government departments should consider ways of dealing with concerns of the public respecting monetary impacts on the public resulting from sour gas blowouts.

6 The ERCB and AE should arrange a symposium to hear expert views on plume modelling/plume impingement and sulphation ground sampling analysis techniques.

12.6 Communication and Co-ordination

12.6.1 Findings

1 The ERCB and most Government departments agreed that their efforts to communicate information about the blowout to the public and the media were generally unsuccessful.

2 The inadequacies of the communication program were a major reason for the broad concerns and fears of the public.

3 There is a need, in the event of a similar incident, for a comprehensive communications program to be implemented immediately. Furthermore, the communications should be a two-way process to ensure that not only does the public understand the plans and actions of those responsible for regaining control of the well, but that those in charge understand, appreciate, and respond to the concerns of the public.

4 The efforts to ensure that the media were fully informed for it to properly carry out its essential role of keeping the public well informed were not successful. Co-ordination among Government departments and agencies was reasonably efficient, but was not always perceived as such by the public.

5 A plan that clearly sets out the responsibilities of each of the parties was not in place. Additionally, one agency was not formally responsible for overall co-ordination.

12.6.2 Recommendations

1 A model communication program, along the lines suggested in section 9.4, should be developed by appropriate Government departments and agencies with input from the public and industry.

2 The "Peacetime Emergency Operations Plan For a Sour Gas Release", recently issued by ADS, should be reviewed in light of the Panel's recommendations.

3 The establishment of a "command post" organizational structure should be confirmed and implemented for all significant blowouts.

12.7 Adequacy of ERCB's Responses Following the Blowout, and Its Regulations, Policy, and Procedure

12.7.1 Findings

1 The ERCB met all existing requirements in licensing the 13-12 well.

2 The experience gained from the blowout, together with evidence presented at the inquiry, has convinced the Panel that the regulations and policies did not adequately recognize the critical nature of the operation, given the high volume of H_2S which could be released if a blowout were to occur. Accordingly, special licensing requirements are needed for certain critical sour wells.

3 The Nabors 14E rig was inspected by ERCB staff in accordance with established policy, but inspections by both the ERCB and industry should be increased for critical wells such as the 13-12 well.

4 The ERCB did not have any involvement in the operations in the critical zone prior to the blowout, but the Panel questions whether that was appropriate.

5 ERCB actions were generally adequate with respect to control operations, except that it did not fully recognize the effects the emissions were having on the public.

6 Well-control activities, and accuracy of communication with the public, would have been enhanced if a more accurate estimate of the H_2S concentration and gas flow rate had been available at the time of the blowout.

12.7.2 Recommendations

1 The ERCB, with appropriate input from industry, the public, and other Government departments, should identify wells which are "critical" in terms of avoiding possible blowouts and establish special conditions that must be satisfied by an operator before these wells can be drilled. The ERCB should advise other government agencies of all licences issued for critical wells.

2 The ERCB and other involved Government deparments should establish a plan for their involvement in future emergencies such as the 13-12 well. The plan should include, among other matters, details regarding the responsibilities of various parties, standards for notification and evacuation, and plans for communication with the public and the media. Care should be taken that appropriate municipal officials are aware of the plan.

3 Special efforts should be made to more accurately estimate the potential H_2S release rate for a critical sour well.

12.8 Adequacy of The Government Departments' Responses Following the Blowout, and Their Regulations, Policy, and Procedure

12.8.1 Findings

1 Worker-safety problems occurred during the control operation resulting in the deaths of two workers, and excessive exposure to H_2S by several other workers. The related regulations and procedures were found to be inadequate and require modification.

2 H_2S exposure limits were not clearly established, particularly for persons sensitive to H_2S. An appropriate standard needs to be established for sensitive people.

3 In general, Government departments did not exhibit the appropriate concern for the problems being experienced by the public and did not respond effectively to their inquiries.

12.8.2 Recommendations

1 A government emergency response plan should be put in place for dealing with sour gas releases in the province. Such a plan has been prepared by ADS on an interim basis and will be reviewed in light of this report, comments from the public, and other involved parties. It should be maintained on a current basis. The final plan should address all significant matters relevant to serious sour gas releases and in particular the following:

  (a) the responsibilities and authorities of various departments and agencies,

  (b) the need for a control and communication centre,

  (c) procedures to obtain the best possible estimates of gas flow and composition data,

  (d) the availability of suitable equipment for monitoring,

  (e) ways in which to make communications with the public and media more effective,

  (f) standards, notification, and evacuation criteria and procedures,

  (g) the decision process with respect to possible ignition of wild wells,

  (h) the collection of data for health research purposes, and

  (i) impact of sour gas on animals and crops and ways of better advising rural people respecting these matters.

The public should have the opportunity for input to the plan and should be made aware of its existence when it is in place.

2 OH&S should review its procedures and regulations respecting the suitability and number of breathing apparatuses, the training of workers in their use, review procedures for dealing with workers' health and safety matters for sour wells, and develop a program of direct involvement by senior OH&S staff to be implemented in the event of a blowout. This might be done through a series of workshops.

3 The PBOH should review existing H_2S exposure standards, particularly as they relate to sensitive individuals, in light of experience gained from the Lodgepole blowout.

12.9 Summary

The findings indicate that the 13-12 blowout probably could have been avoided, even allowing for equipment failures, had Amoco followed a policy of cautious drilling in the critical zone and been better prepared to deal with unexpected developments. The public was understandably concerned, frightened, and angry about the blowout. Two workers lost their lives and the public experienced widespread unpleasant health effects. While the evidence suggests to the Panel that the actual long-term physical effects were relatively minor, the legacy of the Lodgepole blowout will influence the Alberta energy resource scene for many years. This is a matter that will require special attention by industry, the ERCB, and Government departments. Special efforts must be made by all parties to avoid another occurrence.

The Panel has made many recommendations that, if fully implemented, can significantly reduce the number of sour gas blowouts in Alberta. Special emphasis has been placed on critical sour wells. Several of the recommendations are for a review of drilling equipment, but the primary emphasis has been placed on the need to reduce blowouts caused by human failures. The Panel has reviewed the inquiry reports issued earlier this year for the blowout at the SHELL ET AL UNIACKE G-72 well, off the east coast, and the loss of the Ocean Ranger drill rig. It also has reviewed the previous ERCB report on the blowout of the 7-10 well which occurred in the same area only 5 years prior to the 13-12 blowout. Each of these three reports indicates that a combination of equipment and human factor causes were responsible for the failures. In each case, the relevant inquiry panel either directly or indirectly indicated that the failure probably would not have occurred had appropriate practices been followed, notwithstanding the equipment problems. The conclusions are thus very similar to the Panel's for the 13-12 well.

The question, then, is how can human factor problems be significantly reduced in drilling operations? The Panel believes that the most effective way would be to ensure that personnel:

(a) are well trained,

(b) are conscious of potential problems and ready to deal with them,

(c) are adequately supported by technical assistance,

(d) follow a sound and safe drilling plan, and

(e) proceed with operations in a cautious manner, particularly while operating in critical zones.

The primary responsibility for ensuring that these objectives are achieved lies with industry and in particular with the company that has been issued a licence to drill the well.

Several of the Panel's recommendations address these issues. The Panel also believes that the ERCB has a responsibility to test whether these objectives are being achieved, and in that regard believes that its inspection system should be carefully reviewed to determine how it can be strengthened to minimize human factor problems.

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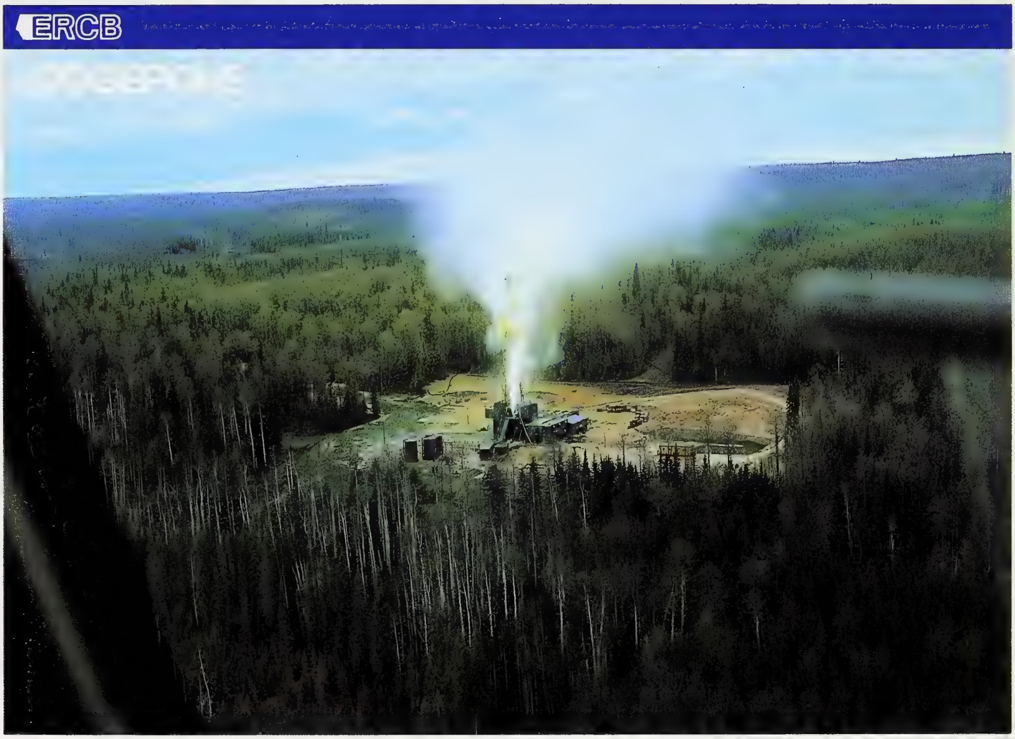

The 13-12 blowout area against its forest background.

Photo credit: W. Wylie, ERCB

13 SIGNIFICANCE OF INQUIRY RECOMMENDATIONS IN REDUCING THE POTENTIAL FOR BLOWOUTS

One of the primary objectives of the inquiry into the blowout of the 13-12 well was to identify changes in drilling operations that could be made which would significantly reduce the likelihood of future blowouts. A related objective was to evaluate the operations that were carried out to regain control of the well to ascertain whether different procedures should be applied in any future cases. Additional primary objectives included determining the degree to which the blowout affected the public, and identifying measures that could have been taken to reduce these effects during the period the well was out of control. This, in turn, could lead to changes in the procedures used to protect and inform the public so that in future emergencies, the effect on the public might be reduced.

In reviewing all of the evidence presented at the inquiry, and in considering the various submissions made by participants, the Panel has arrived at a number of findings and recommendations as summarized in section 12. The key question remaining is, "Would the adoption and implemention of the Panel's recommendations significantly reduce the likelihood of future blowouts, improve the procedures used to regain control if a blowout should occur, and reduce the effect on the public in the event of a blowout?"

The Panel believes the question can be at least partly answered by comparing actual developments at the 13-12 well with what would have occurred if the Panel's recommendations had been in effect and followed. This comparison, of course, is speculative in nature because of uncertainties about the effect some of the suggested changes would have had in this particular instance. Also, because many of the recommendations require additional work by the BPRC and the ERCB, there may be changes in the future which cannot be identified at this time.

Table 13.1 analyses the situation at the 13-12 well with respect to three separate aspects of the incident.

Part A of the table relates to the drilling phase when the blowout occurred and attempts to determine if the recommendations resulting from this inquiry would have significantly changed any of the causal factors of the blowout.

Part B deals with on-site efforts during the blowout to regain control of the well. It attempts to draw conclusions as to whether the recommended changes would have impacted on these efforts and, in particular, have shortened the duration of the blowout.

Part C deals with public effect aspects of the blowout and speculates as to whether the recommendations arising from the inquiry would have lessened the effect on the public of the 13-12 blowout.

The table identifies those factors which were significant for the 13-12 well with respect to one or more of the three phases, and summarizes changes to requirements which would have been in effect had the recommendations contained in this report been adopted prior to the blowout. It then speculates as to the potential effect of these changes on the actual procedures or practices at the 13-12 well and indicates its views as to the significance of the changes at the particular well.

Part A of the table, Drilling Operations, analyses each of the factors which were identified as contributing to the cause of the blowout in section 5 of this report. The Panel found that the following factors were especially significant in contributing to the kick and subsequent blowout:

(a) drilling procedures in the critical zone,

(b) adequate supply of mud, particularly for operations in the critical zone,

(c) use of H_2S resistant drill pipe,

(d) fully effective drilling equipment including a back-up degasser, and

(e) extraordinary caution by drilling crew during critical zone operations and additional supervisory resources during problem period (human factor).

The Panel has made recommendations respecting each of these factors, most of which relate to special licensing requirements for critical sour wells. The need to satisfy the ERCB with respect to the drilling program, the mud system, the equipment to be used, and the level of experience and training for the supervisors and crew would focus considerably more attention on each of the matters that went wrong at the 13-12 well. The Panel believes that had these recommendations been in effect and complied with during the drilling of the well, the blowout probably would not have occurred.

Part B of the table deals with efforts to regain control of the well. The factors listed are those identified in section 6 of this report as having played an important role in gaining control of the 13-12 well. There were a number of areas where the situation might have been helped; for example, a better sour gas flow estimate may have been available. Also, if the original BOP controls would have been at a remote location, and thereby more protected from the H_2S in the escaping gas, there might have been a greater chance of the success of Plan B, as set out in section 6. Effective safety equipment likely

TABLE 13.1 POSSIBLE CONSEQUENCES OF INQUIRY RECOMMENDATIONS ON LODGEPOLE INCIDENT

Phase of Incident	Particular Factor	Changes to Requirements as a Result of Recommendations	Potential Effect of Changes to Procedures	Significance of Changes to Lodgepole
PART A				
Drilling Operations	Geological Information	Detailed geological information required	Better understanding of rock properties, pressures, and of chances of encountering sour gas	Low
- Blowout	Density of Mud	Detailed pressure information required	Higher mud density used	Medium
	Mud Supply	Detailed information required on mud system and actions if problem occurs	Additional mud capacity and/or supplies allowing more sustained circulation of kick	High
	Drilling Procedures	Following prescribed procedures and employing caution	Greater awareness and caution taken	High
	Degasser	Improve degasser design and/or require back-up degasser or alternative	Allow continuous mud circulation	High
	Drill Pipe	Require use of H_2S resistant drill pipe	Drill pipe would be more resistant to failure	High
	Miscellaneous Equipment – gauges, travelling block, kelly hose	More rigorous inspection to ensure sound maintenance	Better supervision should lead to better assurance of all equipment being 100 per cent operational during critical zone penetration	High
	Human Factor	Improved training, hours of work, working conditions, supervision, and assurance of crew qualifications and experience	Assurance of complete awareness by supervisors, service personnel, and drilling crews of critical zone penetration situation and of required drilling procedures and different actions during kick control	High
PART B				
Regaining Control	Volume of Blow, H_2S and Condensate Content	Detailed information required	Better estimates of flow	Medium
	Site-Specific Emergency Planning	Planning would be in greater detail	More detailed knowledge of rig equipment and capability to implement specific control procedures	Medium
	BOP Equipment	Additional information required	Remote location for master controls	Medium
	Safety Equipment and Procedures	Detailed information required	Better equipment and increased awareness of importance and perhaps avoidance of serious accident	High
	Igniting Well and Drilling of Relief Hole	General plans required and system in place to ensure full awareness of concerns of the public	Somewhat more complete assessment of control options and blowout effects could limit period when well unignited	Low
PART C				
Effect on Public	Site-Specific Emergency Response Plan	Plan would be required	More organized and timely response to protect the public	Medium
	Volume of Blow, H_2S and Condensate Content	Detailed information required	Better estimates of flow, if available, could assist in assessing occupational risks, public health risks, air monitoring programs, and decisions regarding intentional ignition and/or relief hole	High
	Monitoring	General plans required	Earlier monitoring and more detailed coverage	Medium
	Communications	General program established by Government departments and control centre set up	More effective communication by providing public with information on well blowout status, control plans, monitoring, standards, evacuation, etc.	High
	Co-ordination	General program established by Government departments and control centre set up	More effective contact among Government departments and less chance of conflicting statements or directions	Medium

would have enabled Plan C to be successful. Additionally, greater attention would likely have been given to the broad reactions of the public in deciding whether to intentionally ignite the well. While this almost certainly would not have resulted in igniting the well, it may have meant that well control Plan C, which involved extinguishing the well after it had accidentally ignited, might have been rejected and efforts to control the well while on fire might have been initiated sooner.

Part C of Table 13.1 analyses the situation with respect to the effect on the public of the 13-12 blowout. The factors listed in the table are those identified in sections 7, 8, 9, and 10 as having been particularly significant in terms of the effect on the public.

The table indicates that there would have been major changes if the recommendations contained in this report were in effect before the blowout. In particular, there would have been a site-specific emergency response plan and a general sour gas emergency plan in place. These almost certainly would have resulted in a much improved communications approach with the public and the media, and to the establishment of a control centre which would have directed overall operations and handled all information requests and complaints from the public. Since one of the major effects on the public appears to have resulted from uncertainties and related anxieties, most of which stemmed from insufficient information respecting the blowout, control plans, health standards, monitoring, and evacuation criteria, it follows that the changes would likely have improved the public's perception of the situation substantially. They would not, however, have affected the health effects described previously in section 7, except to the extent that the decision to cap the well while on fire may have been made earlier.

In summary, the Panel believes the recommendations contained in this report, and summarized in section 12, would have had a real impact on the event had they been in place prior to the 13-12 blowout and had they been adhered to throughout the planning, drilling, and other phases. In particular, with the changes in the planning and drilling, the blowout would probably have been avoided. However, if it had occurred, there would have been a potential to modestly expedite control operations or at least ensure that the concerns of the public were being properly considered when making decisions respecting control options. Finally, public anxiety and concern would almost certainly have been significantly lessened through an improved and co-ordinated communication program.

The Panel believes that these conclusions respecting the likely significance of the recommendations on the 13-12 incident can be extrapolated into the future for all wells to be drilled in the province. It is satisfied that the recommendations will, if fully implemented, significantly reduce the frequency of blowouts, particularly for critical sour wells.

The key factor lies in their implementation and in overcoming problems caused by human failure. As indicated previously, the Panel believes that can best be achieved by exercising extreme caution while carrying out operations in the critical zone. The Panel urges both industry and the ERCB to take any action necessary to ensure that care and caution become the operating philosophy in drilling critical sour wells.

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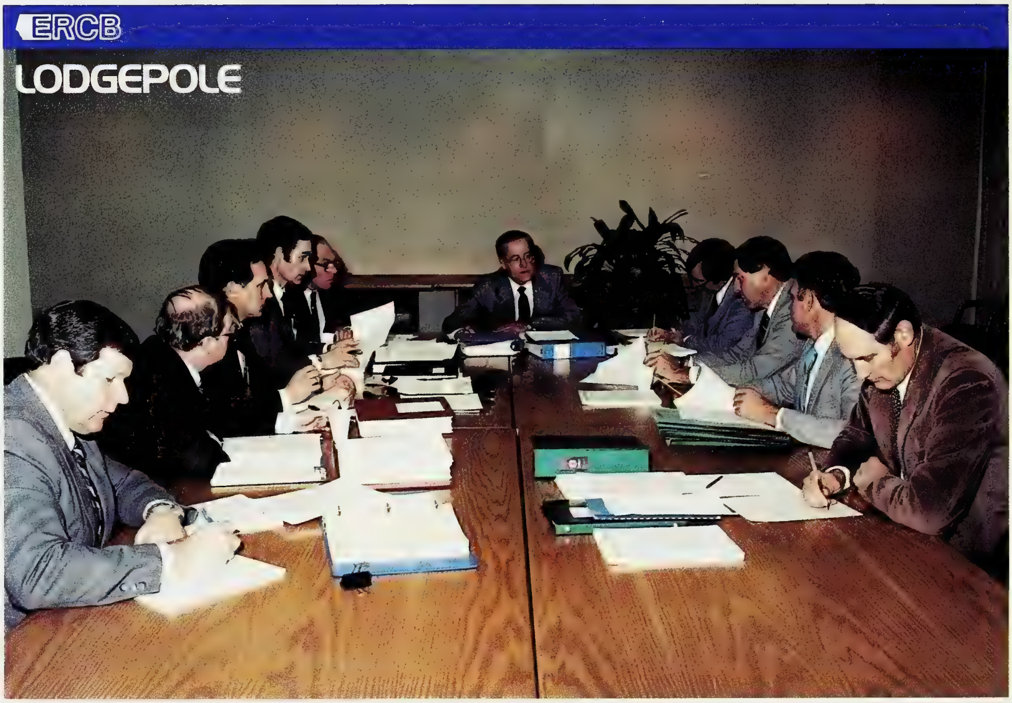

The Blowout Prevention Review Committee (BPRC) seeking ways to prevent another ''Lodgepole''.

Photo credit: G. Brosinsky, ERCB

14 REPORT ON DEVELOPMENTS SINCE THE RELEASE OF THE PHASE 2 REPORT

14.1 Introduction

In April 1984, the Panel issued its Phase 2 report (see Appendix 5). The report included a wide range of recommendations which were categorized by the Panel as to their relative importance. Most of the recommendations related to ERCB responsibilities and it indicated that immediate action would be taken to either implement or examine those recommendations that had the highest priority. The primary purpose of this section is to provide a brief summary of the current status of those activities.

During the last 7 months, many representatives of industry, the ERCB, and where appropriate, the public and Government departments have devoted substantial time and effort to the consideration of the specific issues assigned to them. To illustrate, 45 different people have served in 53 positions of the BPRC or its subcommittees. It is estimated that these persons and others directly involved in BPRC activities to date have contributed 40 man-months of time. An additional 30 man-months is thought necessary to complete the Phase 2 activities.

14.2 Recommendations in the Phase 2 Report

The following lists each of the recommendations contained in the Phase 2 report and provides a brief description of its current status.

1 Establish special controls for selected sour wells that, in case of a blowout, have a potential for emitting large volumes of sour gas – especially if the wells are to be located near residential areas (section 5.1.1)[1].

A Draft Interim Directive was issued by the ERCB in April 1984 (Appendix 5 of Appendix 5) which defined critical sour wells and the site-specific emergency plan, well planning, and supervision that is required. To date, 12 wells have been licensed in accordance with these requirements. Comments on the ID were solicited from industry, government, and the public and these are now being considered.

2 Establish a joint industry/ERCB committee to review ERCB rig inspection procedures (section 3.3.3).

The committee was formed and has developed a large number of recommendations that will result in more effective inspections and increased enforcement. The reporting of inspection results has been expanded to keep industry fully informed and better able to self-regulate. By late November 1984, most of the committee's recommendations had been implemented.

3 Review the availability of blowout insurance and the advantages it may have to ensure adequate funds in case of a blowout (section 5.2.4).

An internal ERCB committee has studied the many variations and refinements of blowout insurance that are available. Representatives of the oil and gas industry and insurance industry have been interviewed to determine current practice. Government agencies in Canada, the United States, and Europe have been contacted to determine what is being done in other jurisdictions. A report is being prepared and will be provided to industry and the public for comment.

4 Develop criteria for igniting a sour gas well in case of blowout (section 5.2.1).

ERCB staff have developed draft criteria based in part on their experience with the emergency plans they presently review and approve for sour wells. These proposed criteria will be discussed with industry, Government departments, and the public.

5 Review safety aspects of sour well drilling, especially with respect to breathable air supply (section 5.3.1).

The matter of worker safety at the rig site is within the jurisdiction of OH&S. The ERCB decided to delay a request to OH&S to initiate the broad study until after the Lodgepole Phase 1 report becomes available. Notwithstanding that decision, OH&S has been kept informed of BPRC activities, and is represented on two BPRC subcommittees (Training and Detection).

6 Establish a committee to review technical and economic issues related to blowout prevention (section 4.2).

The BPRC was established as a joint industry/ERCB committee with provision for participation by representatives of the public and Government departments as appropriate. The assessment and recommendations of the BPRC will be made public and will be subject to review and comment by all interested persons when they become available. Each of the many issues presented to the committee have been considered and an appropriate course of action for each determined as follows:

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[1] Section references refer to the Phase 2 report included in Appendix 5.

(a) Review training requirements (section 5.1.2).

A joint industry/ERCB subcommittee was established which started by defining a hypothetical sour well and then determining the skills and training requirements of the personnel required to plan and drill the well. The training requirements will be compared to what is now available and from this, the deficiencies in present training will be identified.

(b) Review frequency and timing of industry and ERCB rig inspections, and enforcement of requirements (sections 5.1.3 and 5.1.4).

A joint industry/ERCB subcommittee was established which has recommended daily and weekly inspections by drilling rig supervisory personnel, and ERCB inspections keyed to drilling progress. Alternative for enforcement were considered and the suspension of drilling progress, in case of "serious" deficiencies, has been recommended.

(c) Review a large number of equipment-related concerns with particular emphasis on BOP equipment for sour gas drilling (section 5.1.6).

Two joint industry/ERCB subcommittees have been established, one to review the BOP stack and the second to consider associated equipment such as drill pipe and BOP manifolds. Because of the number of problems they faced, both subcommittees have divided into task forces to address specific matters, such as the requirements for drill pipe in sour gas service. All the task forces have initiated their studies and are interacting at the subcommittee level as required.

(d) Review techniques available to monitor for warnings of drilling problems, such as a kick or the presence of H_2S (section 5.1.6).

A joint industry/ERCB subcommittee has been established which has reviewed equipment and procedures presently available to monitor at the surface as well as at the bottom of the well. Limitations in present technology have been identified and areas of potential improvement will be determined.

(e) Consider the merits of developing an Alberta Code of Practice for Drilling (section 5.1.11).

The BPRC has discussed the kind of guidelines that are needed and are not satisfied by the present regulations, company procedure manuals, or industry association manuals. Some tentative concepts have been developed and these will be reviewed and developed further after the Lodgepole Phase 1 report is available.

(f) Consider the need to develop guidelines for winter drilling (section 5.2.1) and mud system design (section 5.1.10).

The BPRC has concluded that these matters and some aspects of well planning (section 5.1.9) should be considered in conjunction with a code of practice that might be developed.

(g) Review the merits of special supervision requirements while drilling sour wells, especially where the sour zone has been penetrated (section 5.1.5).

Since the Draft Interim Directive (item 1) requires increased supervision at critical sour wells, the BPRC decided to defer consideration of this question until it had acquired some experience with those requirements.

(h) Consider the need to improve the availability of information that would assist in learning more about blowouts and their prevention (sections 5.1.7 and 5.1.9).

The BPRC has obtained information on the services that are now available from scientific and technical libraries, commercial information services, Government agencies such as the Alberta Research Council, and the ERCB. These will be compared to the information needed to prevent blowouts generally, and to plan the drilling of a specific well to determine if gaps exist.

(i) Review the merits of having a co-operative pool of equipment that would be needed in case of a blowout (section 5.2.5).

The need and practicability of such a pool is being considered by the BPRC, having regard for previous blowout experiences and experience in the past with similar equipment pools.

(j) Analyse the effect of human factors such as training, health, and hours of work on safety and preventing blowouts (section 5.1.2).

Consideration of this matter by the BPRC has been deferred pending availability of the Lodgepole Phase 1 report.

The Drilling Rig Inspection Committee filed its report with the ERCB in June 1984 and the BPRC has filed two progress reports with the ERCB. All three reports were mailed to participants of the inquiry, and copies are available to the public at the ERCB offices in Calgary.

ISSUED at Calgary, Alberta, on 11 December 1984.

LODGEPOLE BLOWOUT INQUIRY PANEL

V. Millard
Inquiry Panel Chairman

John Markham

J. W. Markham, M.B.
Panel Member

GJ DeSorcy

G. J. DeSorcy, P.Eng.
Panel Member

N Strom

N. A. Strom, P.Eng.
Panel Member

FA Herbert.

F. A. Herbert, M.D.
Panel Member

Sherman Weaver

R. S. Weaver, Ph.D.
Panel Member

APPENDIX 1 GLOSSARY OF TERMS

alkaline formation water – water originally in place in a formation and containing a high concentration of hydroxyl ions in solution.

ambient – meaning surrounding, or on all sides. Ambient is generally used to describe the condition of a larger body in which the subject of interest is located.

ampoule, crush – a small, gauze wrapped, glass vessel containing liquid lead acetate which, when crushed, permits the lead acetate to impregnate the gauze wrap. In the presence of hydrogen sulphide, the lead acetate will turn various shades of brown depending on the concentration of hydrogen sulphide present.

annular preventer – a large valve, usually installed above the ram blowout preventers, that forms a seal in the annular space between the pipe and wellbore, or if no pipe is present, on the wellbore itself.

annulus – the space between two concentric pieces of pipe or between a pipe and the hole in which it is located.

anorexia – chronic or constant lack of appetite for food.

aquifer – an underground layer of porous rock, sand, etc, containing water, into which wells can be sunk for water supply purposes.

benthic organisms – all the plants and animals living on or closely associated with the bottom of a body of water.

blind ram – an integral part of the blowout preventer, serving as the closing element. Its rams do not fit around the drill pipe but seal against each other.

block hook – a travelling assembly of one or more pulleys which can be hoisted or lowered in the derrick. The hook is an integral part of the block to which the elevators can be attached. The drill pipe can, in turn, be latched into the elevators and thus raised or lowered in the derrick by the travelling block.

blowout – an uncontrolled flow of gas, oil, or other well fluids into the atmosphere.

blowout preventer (BOP) – the valve-like equipment attached to the casing at a drilling rig used to prevent a blowout.

bottom-hole mud column pressure – the hydrostatic pressure exerted by a static column of drilling fluid (mud) at the bottom of a drilled hole. It is equal to the true vertical depth of the hole multiplied by the specific weight of the drilling fluid.

bottoms-up time – the time required to circulate drilling fluid from the bottom of the hole up the wellbore to the top of the hole.

BOP stack – the combination of valve-like devices, piping, and other fittings attached to the casing at a drilling rig, and designed to prevent a blowout.

carbonate bank – in petroleum geology, a sedimentary structure composed of calcium carbonate (limestone) or calcium magnesium carbonate (dolomite), sometimes making up a petroleum reservoir.

casing (surface, production) – the steel pipe placed in a well to prevent the collapse of the hole and provide a conduit for fluids during the drilling and producing phases.

APPENDIX 1 (continued)

casing pressure	– the pressure in the casing drill-pipe annulus.
casing shoe	– the bottom end of the casing.
central nervous system	– that part of the nervous system consisting of the brain and spinal cord.
choke	– a valve designed to control flow rates.
choke manifold	– the arrangement of piping and chokes through which drilling mud is circulated to control pressures encountered during a kick.
chronic bronchitis	– the persistant inflammation of the mucous lining of the bronchial tubes.
circulating	– the pumping of drilling fluids down the drill pipe, out through the drilling bit, up the annulus, and back to the mud tanks.
condensate	– that part of natural gas that is liquid at normal atmospheric conditions.
coring	– a drilling operation which uses a special bit to produce a cylindrical sample or core of the rock penetrated.
critical sour well	– a critical sour well has been defined by the ERCB in its Draft Interim Directive issued in April 1984. See Appendix 5 of Appendix 5.
critical zone	– in drilling operations, the critical zone is a zone containing sour gas, generally the target formation.
cytochrome c-oxidase	– cytochrome – any of several iron-containing enzymes found in almost all animal and plant cells, and which are very important in cell respiration.
	– oxidase – any of a group of enzymes which catalyze oxidations.
degasser (mud-gas separator)	– a device which removes formation gas and air from drilling mud.
doghouse	– a small enclosure near the rig floor for protection from the weather for the drilling crew and drilling documents and small tools.
drainage sump	– an earthen pit dug on the lease site for the purpose of collecting potentially contaminated drainage water from the lease.
drill pipe	– the heavy seamless pipe used to rotate the drilling bit and circulate the drilling fluid.
drill string	– the column or string of drill pipe, not including the drill collars or kelly. Often, however, the term is loosely applied to include both the drill pipe and drill collars.
drilling	– the rotating of the drill pipe and bit and the circulating of drilling mud to cause penetration of formations.
drilling program	– a document prepared by the licensee of the well which contains instructions, diagrams, and other pertinent information and is the approved procedure for drilling the well.
drilling spool	– a spacer between components of the BOP stack, containing valved outlets.
emphysema	– a lung condition marked by loss of elasticity of the air sacs (alveoli), causing difficulty in breathing.
enzyme	– a protein able to initiate or accelerate specific chemical reactions in the metabolism of plants and animals; an organic catalyst.

epidemiological studies	the study of the causes and control of widespread and simultaneously occuring health afflictions or epidemics.
excess fluid head	the pressure exerted by a column of fluid at rest in excess of that which is desired or permissible.
fishing	an operation to recover equipment such as broken drill pipe that has been lost in the wellbore.
flare line	a metal pipe running from the choke manifold or from the degasser, terminating at an earthen pit in which gas encountered while drilling may be burned.
flow nipple	used on the top BOP as a guide for the bit and to direct the mud flow from the well to the mud tanks. Also referred to as a drilling nipple.
formation	a subsurface layer or deposit that is composed throughout of substantially the same kind of rock.
formation pressure	the pressure exerted by fluids in a formation. It is also called reservoir pressure or shut-in bottom-hole pressure.
fracture planes	cracks in a formation that usually occur primarily in one direction or plane (eg, horizontal).
gastrointestinal	having to do with the stomach and the intestines.
geolograph charts	the paper recordings made by the Geolograph, a patented device that automatically records the rate of penetration and depth during drilling.
goose neck	the curved connection between the kelly hose and the swivel.
gradient	the rate of change, eg, pressure with depth.
gravel berm	a narrow ledge, shelf, or shoulder composed of gravel.
hold-down equipment	a mechanical arrangement that prevents the upward movement of equipment installed in a well.
hydraulic	an action similar to buoyancy, caused by the movement and pressure of a liquid. In blowout situations, the upward force on drill pipe in the hole due to the movement and pressure of the drilling fluid.
hydrogen embrittlement	the loss of a material's ductility, or ability to deform without fracturing. This is thought to be due to the absorption of hydrogen atoms into the material usually in the presence of water and/or hydrogen sulphide.
hydrogen ion attack	see hydrogen embrittlement.
hydrogen sulphide (H_2S)	a naturally occurring poisonous gas.
H_2S scavenger	a material that deactivates any H_2S entering the wellbore.
hydrostatic pressure	the pressure exerted by a column of fluid such as the drilling mud in the wellbore.
inside BOPs	equipment designed to prevent blowout fluids from escaping up the inside of the drill pipe.
interim directive	announces and prescribes new ERCB policy and requirements. The new policy is normally incorporated into the appropriate regulations at a later date.
intermediate casing	the string of casing set in a well after the surface casing to keep the hole from caving.

ion – an electrically charged atom or group of atoms, the electrical charge of which results when a neutral atom or group of atoms loses or gains one or more electrons during chemical reactions by the action of certain forms of radiant energy, etc. The loss of electrons results in positively charged ion (cation), the gain of electrons in a negatively charged ion (anion).

ionization – to change or be changed into ions, eg, as a salt dissolved in water.

iron oxide (Fe_3O_4) – a chemical compound which is used as a hydrogen sulphide scavenger.

isopleth – an imaginary line surrounding a point of potential contaminant release, formed by joining points of equal potential contaminant concentration (similar to a contour line).

kelly – the heavy steel member, four- or six-sided, suspended from the swivel through the rotary table and connected to the top-most joint of drill pipe. It is used to turn the drill stem as the rotary table turns. It has a bored passageway that permits fluid to be circulated into the drill stem and up the annulus, or vice versa.

kelly bale – a cylindrical steel bar (similar to the handle or bale of a bucket, only much larger) that supports the swivel and connects it to the hook.

kelly hose – the hose on a rotary drilling rig that conducts the drilling fluid from the mud pump and standpipe to the swivel and kelly; also called the mud hose or the rotary hose.

kick – the flow of gas, oil, water, or other formation fluids into the wellbore.

kill (top kill) – the pumping of high density mud down a wellbore without drill pipe in the hole to overbalance formation pressure.

kill spool – a device that connects two BOPs and provides a method of attaching the kill and bleed-off lines to the wellbore. Also known as a drilling spool.

kill stack – an assembly of BOPs and related equipment attached to the top of the casing. Generally, the annular preventer is located above two, three or even four ram-type preventers.

lost circulation – the loss of drilling fluid from the wellbore into a permeable formation.

master control panel – a set of controls that operate the BOPs directly. In contrast, auxiliary or secondary controls operate the BOPs by activating the master control.

monkey board – the derrickman's platform that raises him to the proper height to handle the top of the drill pipe as it is run into or out of the hole.

mud (drilling) – the liquid circulated down the drill pipe and up the annulus during drilling.

ocular – having to do with the eyes or eyesight.

olfactory – having to do with the organ of smell (nose) or pertaining to the sense of smell.

one-window concept – a concept whereby all communication is relayed through a single person or office in order to make the communication process more efficient.

permeability – a measure of the ability of fluids to flow through rock.

pH – the acidity or alkalinity of a fluid; a measure of hydrogen ion activity.

piezometer – an instrument or drilled hole used to measure pressure or direction of flow.

APPENDIX 1 (continued)

pinnacle reef formation	– a geological term referring to a spire-like formation usually composed of limestone, in which hydrocarbons may be trapped.
pipe ram	– a sealing component for a blowout preventer that closes the annular space between the pipe and the blowout preventer or wellhead.
pipe stripper	– a device which removes mud from the drill pipe exterior, through the use of rubber wipers, as the pipe is being withdrawn from the hole.
porosity	– the open or void space within a rock.
porous formation	– a bed or deposit composed throughout of substantially the same kind of rocks and containing openings or small spaces within the rock that are usually filled with some fluid, such as oil, water, or gas.
positive pressure air supply	– a system used in breathing apparatus whereby the face mask is provided with an air supply of greater pressure than atmospheric pressure, to prevent infiltration into the mask of potentially harmful gases.
prehydrated bentonite	– bentonite is a type of clay which is used to increase the viscosity of fresh water, and aid in suspending drilled cuttings. Prehydrated bentonite is mixed and stored in a tank to reduce the time required to mix dry bentonite in an emergency situation.
pup joint	– a length of drill pipe, tubing, or casing shorter than the usual 30 feet.
relief well	– a well drilled near and deflected into a well that is out of control, making it possible to bring the wild well under control.
respiratory tract	– the system of organs involved in the exchange of carbon dioxide and oxygen between an organism and its environment.
riser	– a pipe through which liquid travels upwards; a riser pipe.
seepage losses	– the escape of the liquid part of a drilling mud into permeable formations; also known as filtration loss.
shear rams	– a component of the BOP stack that can cut or shear through the drill pipe and form a seal against well pressure.
sloughing shales	– the collapse of the walls of the wellbore due to the swelling and crumbling of shale when exposed to water.
sour gas	– natural gas containing H_2S in measurable concentration.
soil microbiology	– the branch of biology that deals with the microscopic or ultramicroscopic animal or vegetable organisms found in the soil.
spill-control boom	– a series of linked, floating barriers intended to contain and limit the spread of a pollutant spill on water.
spud in	– to start drilling the wellbore.
sulphur dioxide (SO_2)	– a poisonous gas formed by burning hydrogen sulphide.
surface casing bowl	– a heavy metal fitting which is usually welded to the top of the surface casing and which provides a means by which the blowout preventers and the wellhead may be attached.
surge pressure	– a pressure wave caused by the rapid lowering of the drill pipe in the confined space of the wellbore.

APPENDIX 1 (continued)

swabbing – to cause a sucking action within the wellbore by pulling the drill pipe up the wellbore too quickly and accelerating or inducing the invasion of formation fluids.

sweet oil – oil containing little or no sulphur and hydrogen sulphide.

systemic toxicological effects – the effects of poisons upon an entire organism or bodily system.

testing – a procedure to test the type and quantity of fluids contained in a formation.

tracheobronchial tree – relating to the trachea and bronchi.

travelling block hook latch – a fastening device on the travelling block hook used to secure the bale of the swivel and prevent it from coming out of the hook.

trip air – air that enters the drilling mud system during tripping.

tripping (in/out) – the process of pulling all the drill pipe out of the hole to change a drill bit or other bottom-hole equipment, and then lowering the drill pipe back into the hole.

ungulate – animals having hoofs, such as deer and moose.

wash to bottom and clear trip air – circulation of drilling fluid while lowering drill pipe back into the hole. This cleans the hole of drill cuttings and other debris and also flushes air from the joints of drill string as they are added and lowered into the hole.

well effluent – the substances which flow from a well.

wellhead – the equipment used to maintain surface control of a well.

APPENDIX 2 LODGEPOLE BLOWOUT INQUIRY — TERMS OF REFERENCE

1. To inquire into, report upon, and make such recommendations as are necessary or advisable in relation to the events and circumstances leading up to and the cause of a sour gas well blowout which occurred on or about the 17th day of October, 1982, near the Hamlet of Lodgepole, in the Province of Alberta, the events following the blowout, and, without restricting the generality of the foregoing, to inquire into, report upon, and make recommendations in respect of the following matters:

   (a) the suitability of the equipment used to drill the well, and the suitability and adequacy of blowout prevention devices installed thereon,

   (b) the regulations regarding licensing the well, rig inspection, and operation of the well site, the adequacy of such regulations and the enforcement of same,

   (c) the measures used to minimize human error as a causative factor in the blowout, including the training of the drilling crew.

   (d) the actions taken by Amoco Canada Petroleum Company Ltd., and others, to prevent and control the blowout, and the adequacy of such actions, including all aspects of occupational health and safety but excluding the two fatalities that resulted from efforts to control the blowout and which fall within an inquiry under the Fatality Inquiries Act.

   (e) the responses following the blowout, by Amoco Canada Petroleum Company Ltd., the Energy Resources Conservation Board staff, government departments, municipalities and others regarding the protection of human health and welfare, the adequacy of such responses, and how such responses were co-ordinated between various agencies, both governmental and private,

   (f) the impact on and hazard to human health and well-being which may have been created by the emissions from the blowout, and

   (g) the environmental effects of the blowout including the effects on

      (i) air,

      (ii) surface and groundwater systems,

      (iii) soils and vegetation,

      (iv) fish, wildlife, and livestock, and

      (v) equipment, buildings, and other types of personal property, and

      the procedures used to control and minimize such effects, the adequacy of such procedures, and how such procedures were co-ordinated between various agencies, both governmental and private.

2. Further to inquire into, report upon, and make such recommendations as are necessary or advisable in relation to the causative factors of sour gas blowouts in Alberta and actions that can be reasonably taken to minimize the possibility of future occurrences.

3. To inquire into and report upon any matters incidental or relating to any of the matters referred to in paragraphs 1 and 2.

ISSUED BY THE LODGEPOLE INQUIRY PANEL

DATED at Calgary, Alberta on 5 May, 1983.

APPENDIX 3 THOSE WHO APPEARED AT PHASE 1 OF THE INQUIRY

Participants and Representatives (Abbreviations Used in Report)	Witnesses
Amoco Canada Petroleum Company Ltd. (Amoco) A. L. McLarty S. E. Lipton R. A. Neufeld	
Panel 1	N. J. Rubash, President
Panel 2	J. S. Moore, P.Eng. J. Christian C. O. Grasdal, P.Eng. L. J. Field, P.Eng. P. G. McKenna, P.Eng.
Panel 3	J. S. Moore, P.Eng. G. E. Bullock J. Christian L. J. Field, P.Eng. P. G. McKenna, P.Eng. T. W. Phillips A. J. Thomas
Panel 4	J. S. Moore, P.Eng. J. Christian L. J. Field, P.Eng. D. Heenan, P.Eng. A. J. Thomas
Panel 5	J. S. Moore, P.Eng. R. L. Findlay W. A. Murray, Ph.D., of Promet Environmental Group Limited K. L. Fisher and J. H. Westlake of Monitrex Engineering Ltd.
Panel 6	J. S. Moore, P.Eng. R. L. Findlay D. F. Penner of McCourt Management Ltd. B. Bietz, Ph.D. and R. A. Crowther, Ph.D. of Stanley Associates Engineering Ltd. – IEC Beak Consultant Ltd.
Panel 7	J. S. Moore, P.Eng. R. L. Findlay K. Campbell of Campbell Geoscience Ltd. J. M. Crepin, P.Ag., of Norwest Soil Research Ltd.

APPENDIX 3 (continued)

Panel 7 (cont'd)	P. Eligh of Woodland Resource Services Ltd. D. R. Jaques of Ecosat Geobotanical Surveys Incorporated A. H. Legge, Ph.D. of Kananaskis Centre for Environmental Research and University of Calgary B. Valleau of Western Reclamation Services Ltd.
Panel 8	J. S. Moore, P.Eng. R. Eshpeter W. A. Heth, P.Eng. D. Smith
Panel 9	M. R. Young, M.D., Ph.D. T. H. Milby, M.D., M.S.H. R. P. Smith, M.S., Ph.D.
Panel 10	N. J. Rubash, President
Nabors Drilling Limited (Nabors) D. G. Hart, Q.C.	T. L. Doyle, P.Eng. E. Berg B. Brown W. Randall G. Rode
Energy Resources Conservation Board staff (ERCB) M. J. Bruni D. A. Holgate	L. A. Bellows, P.Eng. E. R. Brushett, P.Eng. R. L. Paulson, C.E.T. J. E. Reid, C.E.T. W. W. Wylie
Alberta Government Departments (Government departments) J. W. Beames, Q.C. A. R. Watson	Alberta Agriculture (AA) R. G. Christian, Ph.D. B. E. Beck, Ph.D. G. G. Klavano, D.V.M. L. E. Lillie, D.V.M., Ph.D. D. Walkey Alberta Forest Service Division (AFS) of Energy and Natural Resources (E&NR) J. E. Benson E. G. Jaap A. B. McFadyen Fish and Wildlife Division (AFW) of Energy and Natural Resources G. Thompson C. A. Hunt K. Smith D. Wig

APPENDIX 3 (continued)

Alberta Government (cont'd)	Occupational Health and Safety Division of Workers' Health, Safety and Compensation (OH&S) B. J. Johnston I. Arnold, M.D., M.S.C. J. MacPherson E. Ung A. Weiss
	Alberta Disaster Services (ADS) I.D.M. Egener E. Tyler B. Bennett S. R. Langman
	Social Services and Community Health (SS&CH) and Provincial Board of Health (PBOH) S. M. Durkin, M.D. Y. Bhambhani, Ph.D. J. M. O'Laney R. R. Orford, M.D. R. E. Rogers, Ph.D. J. R. Waters, M.D. E. J. Love, M.D., Ph.D. M. L. Russell, M.D.
	Alberta Environment (AE) E. E. Kupchanko, P.Eng. R. N. Briggs, P.Eng. J. F. Kostler, P.Eng. S. Sakiyama A. R. Schulz, P.Eng.
Edmonton Area Respiratory Patients (EARP) W. W. Smart	C. May G. McPherson M. Semaka A. S. Clanachan, Ph.D.
N. E. Brown, M.D.	N. E. Brown, M.D.
C. Sams	C. Sams W. Campbell
Town of Drayton Valley	Hon. R. Mayhew, Mayor I. Dykes
Royal Canadian Mounted Police Drayton Valley Detachment (RCMP) P. Kirwin	Staff Sergeant, L. Bannerman
County of Parkland No. 31	Staff Sergeant, R. Steele

Canadian Institute of Public Health Inspectors – Alberta Branch (CIPHI) T. Hodge M. D. MacKenzie	R. Greenwood, Ph.D. T. Hodge
Alberta West Central Health Unit (Health Unit) H. B. Madill	N. J. Bayliss, M.B., B.S., M.P.H., F.R.S.H.
Public Advisory Committee to the Environment Council of Alberta (PAC)	M. S. Kostuch, D.V.M. S. W. Behie, P.Eng., Ph.D., P. R. Guy, B.Sc., M.Sc., and R. L. Johnson, B.Sc., M.Sc. of Monenco Consultants Limited
Health Unit Association of Alberta N. J. Bayliss, M.B., B.S., M.P.H., F.R.S.H.	
Shell Canada Resources Ltd. J. D. Courtwright	
Canterra Energy Ltd., Canadian Petroleum Association, Independent Petroleum Association of Canada, and Canadian Association of Oilwell Drilling Contractors C. P. MacDonald	
Environmental Law Centre L. F. Duncan T. Foley	
City of Edmonton and Edmonton Board of Health M. A. McAvoy	
Pembina Area Sour Gas Exposures Committee (PASGEC) J. C. Prowse, Q.C. D. P. Mallon	Steering Committee R. Macintosh D. Baker O. Baker M. Grinde C. Strach C. Whitelock W. Elton, M.B.A., of WIN Consulting Corporation Ltd. Lodgepole Area Panel D. Baker O. Baker D. Belair L. Nail T. Wentland

APPENDIX 3 (continued)

PASGEC (cont'd)

Violet Grove Area Panel
C. Andersen
C. Andersen
J. Bolianatz
D. McGhee
C. Whitelock

Buck Creek Area Panel
C. Rosell
W. D. Rosell
R. Sackela
A. Wasser

Cynthia Area Panel
R. Beck
M. Grinde
D. Nichols
J. Penner
C. Strach

Easyford Area Panel
D. Huska
J. Huska
B. Kynoch
L. Macintosh
R. Macintosh
D. Vowk

Drayton Valley Panel
J. Benger
E. Gottschalk
O. Guze
J. Rowles
J. Stewart

Health Panel
L. Horstman, B.Sc., M.Sc.
K. E. Josephson, D.V.M., of
Rocky Rapids Veterinary Service
R. Macintosh

R. Cowdery

E. Struzik of
The Edmonton Journal

Informal Session – Drayton Valley, 23 November 1983
Members of the Public

H. Luethi
Mrs. Henkle
S. McConnell
C. Rosell
L. Beckett
D. Gramlich
W. Rosell
L. Smeland
C. Cavanagh
O. Guze
W. Shirvell

APPENDIX 3 (continued)

Informal Session – Edmonton, 8 December 1983 Members of the Public	Mr. Welsh Mr. Barnett L. Mallett	A. Bosman E. Hall C. Sams

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Inquiry Staff

R. D. Schachter
A. R. Currie
D. G. Harrington, P.Ag.
J. K. Moloney
E. J. Morin, P.Eng.
A. S. Murray, P.Eng.
R. W. Reid, Ph.D.

APPENDIX 4 POSITIONS OF THE PARTICIPANTS

Introduction

The following is a summary of the views of each of the participants in Phase 1 of the inquiry. Most of the participants presented evidence and oral argument in support of their positions and responded to questions from the Panel, its counsel, and others. That evidence and the transcripts are part of the public record and have not been reproduced in this report. Rather, the Panel has attempted to synthesize the evidence and arguments into brief summary statements reflecting the positions of each of the participants.

1 Amoco Canada Petroleum Company Ltd. (Amoco)

Amoco's position with respect to the various matters considered at Phase 1 of the inquiry can be summarized as follows:

1.1 The geological knowledge of the area prior to the drilling of the 13-12 well was such that a sweet oil well was anticipated by Amoco as the likely result. Drilling would not have proceeded had it been known that sour gas would be encountered but the involved personnel were aware of that possibility. However, there would have been no significant changes in the planning for or equipment and procedures used had the well been drilled with the knowledge that sour gas would result.

1.2 The cause of the blowout can likely be traced to an initial influx of sour gas into the wellbore during coring operations when the drill pipe and coring assembly were pulled up off the bottom of the hole to insert a small joint of pipe. The gas was not fully circulated out of the mud system due to the failure of the degasser, which is intended to separate the gas from the mud. The degasser float valve, which is intended to allow the mud to circulate into the tank while diverting the gas to a flare, became stuck on two occasions, forcing a halt to the circulation of the mud down through the centre of the drill pipe and up around its outside.

These failures were worsened by cold weather and coupled with other equipment problems allowed additional volumes of gas to enter the wellbore. The problems also caused the circulation of mud to be halted several times leaving the sour gas in contact with the drill pipe for longer than normal. The H_2S in the gas caused embrittlement of the pipe and it subsequently parted several hundred metres below the floor of the drilling rig. The pressure in the wellbore then caused the pipe to be forced upward out of the hole. This severed the kelly hose connection to the drill pipe thus allowing the well to blow out through the centre of the pipe.

1.3 The Nabors rig used by Amoco was more than adequate to drill the planned well and it had been inspected and found satisfactory by senior Amoco personnel prior to its service for the company.

1.4 Amoco decided to use Grade G high-carbon steel drill pipe as part of the drill string in order to have pipe with sufficient tensile strength to drill a directional hole to a depth of some 3200 m even though it recognized that the pipe would be more susceptible to H_2S attack. In future similar situations, Amoco said it would use Grade E pipe of greater wall thickness but defended the choice of its drill string as suitable given the existing circumstances and expectations when the 13-12 well had been planned.

1.5 The closed-type degasser, with a float valve on which its functioning is dependent, which was on the Nabors rig, had been used without serious problems on most rigs drilling in very cold climates where the mud tank and equipment were housed. The choice of such equipment was therefore justifiable. On the basis of the problems encountered, Amoco would in future require an open-bottom unrestricted flow-type degasser with a by-pass if repairs became necessary.

1.6 The overall drilling mud program including the volume of ingredients and equipment available to mix the mud, the density, and other properties of the mud in use at the time of the blowout, and the use of iron oxide in the mud as an H_2S scavenger, were all in accordance with sound practices and were not the direct cause of the blowout.

1.7 The blowout prevention equipment, the manner in which it was installed, and the testing of it as required by Amoco more than exceeded the requirements of the ERCB and acceptable industry standards.

1.8 Amoco personnel and the Nabors drilling crew were all well-trained individuals with more than sufficient experience to drill the subject well located in a sour gas prone area. Also, adequate planning meetings to review blowout prevention and sour gas kick-control procedures took place to ensure that the personnel were adequately familiar with the planned drilling program. Additionally, even though the senior supervisory personnel were forced by problems to work very long hours during the night and morning of 16 and 17 October, they were completely capable of properly discharging their responsibilities and their long periods on duty did not contribute to the cause of the blowout.

1.9 The well site was selected and prepared for drilling in a manner completely consistent with the terrain and so as to reduce potential environmental impacts.

1.10 The drilling of the well, including the setting of surface and intermediate casing and the use of directional drilling equipment, to the top of the Nisku zone was relatively routine and that part of the operation played no part in the cause of the blowout.

1.11 The planning with respect to safety, including procedures if H_2S gas was encountered, was properly done and complied with regulatory requirements and industry standards.

1.12 The actions taken during the night and morning of 16 and 17 October while problems were being encountered were consistent with kick-control and other industry accepted procedures. These included activities at the time gas was noted bubbling out of the casing, when the degasser failed on two occasions, and when the drill pipe parted. Amoco acknowledged that alternative actions could have been followed by those responsible, possibly with greater success, however, the decisions taken were all logical and sound given the circumstances that existed at the time.

1.13 The Amoco emergency response plan, although general in nature, was appropriate for dealing with the blowout. Under terms of the plan, the blowout was a Condition IV, the most extreme designation recognized.

In terms of the on-site situation, adherence to the plan resulted in the immediate notification of senior company personnel, engagement of well- control specialists, notification of the ERCB, and plans for control procedures. It also included general plans for on-site safety and for securing the site from the public.

With respect to the off-site situation, the Amoco emergency response plan was adequate to ensure that immediate steps were taken to protect the public during the period when Amoco and involved government representatives were developing more specific plans to deal with off-site problems.

1.14 The personnel used to bring the well under control, both from within the Amoco organization and from outside specialist companies, were well trained and had the proper experience to deal with the blowout. Amoco emphasized that the change in well-control specialists that took place during the latter stages of the blowout period was made because the strategy changed to one of capping the well while on fire. This necessitated the change since the first specialist company was not prepared to undertake the operation while the well was burning.

1.15 The equipment necessary to control the well was available as needed and did not significantly delay well-control operations, in part, because Amoco was able to marshal considerable resources to bring it in from remote locations or fabricate it as appropriate.

1.16 The weather conditions during capping operations, and particularly atmospheric conditions that caused H_2S gas to build up around the well site, significantly impacted on control operations and lengthened the period over which the well blew wild.

1.17 The plans to cap the well, and particularly the sequence of the various methods attempted, were well thought out and technically sound.

The first plan was to lower a new blowout preventer over the drill pipe stub and bolt it to the preventer in place. Amoco acknowledged that the failure of its own personnel and those of Nabors to recall that an automatic pipe cleaner was installed as part of the rig facility meant that several days were spent in preparing for this particular procedure which, in the final analysis, could not be attempted. It stressed that much of the work during that period would, however, have been needed in any case.

The second plan was to open the pipe blowout preventers, drop the drill pipe into the hole, and then close the other preventers (blind rams which closed against each other). Amoco said it recognized the pipe might blow out of the hole rather than drop (as it did, causing the first fire), but that this plan was still the best available and had to be tried.

The third plan was to extinguish the flame with explosives and lower a new control assembly over the casing stub. This plan was aborted by an accident which occurred a few minutes before it should have succeeded.

The well subsequently caught fire and was capped while on fire by installing a new control assembly.

1.18 The decision in the early stages to cap the well when it was not on fire, and thus was emitting H_2S, was taken because of added difficulties in capping a burning well. Such a procedure had been accomplished on only six previous occasions. The later decision to attempt to control it while it was on fire was taken because of the widespread nuisance effects that were occurring and because of public concerns.

1.19 The on-site safety procedures during the blowout were in accordance with accepted procedures and all regulatory requirements. Experienced safety personnel were engaged and were given proper authority, and equipment consistent with the existing safety hazard was available at all times. Problems which did occur were the result of unexplained and unique circumstances and could not reasonably have been avoided.

1.20 Amoco personnel on site at the time of the blowout had authority to ignite the well, thus converting the H_2S to SO_2, if the H_2S represented an immediate serious threat to the safety of the public. Immediate ignition was not necessary, but Amoco remained prepared throughout the blowout to ignite the well at any time the public was threatened.

1.21 Plans were put in place, including site preparation and allocation of a rig to drill a relief hole, if surface attempts to kill the well were unsuccessful. This approach was not used, however, because it would require some 65 to 80 days to drill a relief hole and then the procedure might not be successful.

1.22 Amoco agreed with the one-window concept in terms of contacts with Government departments and agencies and dealt primarily with the staff of the ERCB.

1.23 The site was properly secured from the public and access was accorded only to those parties involved in well-control operations and only with adequate safety equipment.

1.24 Off-site monitoring for H_2S was taking place within hours of the beginning of the blowout and continued whenever H_2S was being emitted. The amount of monitoring was more extensive than had occurred in a single area on previous occasions in that nine monitors, five mobile and four stationary, were used.

The number of monitors, the region being monitored, and the concept of portable monitors following and attempting to establish areas of peak concentration were adequate to ensure the safety of the public.

1.25 Residents in the immediate area of the 13-12 well and of the community of Lodgepole were informed of the blowout and the possible need for evacuation. The members of the public not contacted were generally farther from the well site and were not in substantial danger.

1.26 Upon request, residents of the immediate area that believed they were experiencing health impacts were moved at Amoco's expense. Some 28 persons were moved to locations ranging from Drayton Valley to Edmonton for periods of up to a week or more but generally in the order of one day.

1.27 Amoco, on the basis of its involvment with government representatives, understood that the following guidelines for notification and evacuation of the public were adopted:

(a) For H_2S at 5 ppm for 6 hours or 10 ppm for 1 hour, residents would be notified of the levels and evacuation would be recommended.

(b) For H_2S at 15 ppm with an upward trend or any reading of 20 ppm would bring about a mandatory evacuation.

(c) For SO_2, 0.3 ppm for 24 hours would result in notification and recommended evacuation of residents.

Amoco undertook to be responsible for the notification process and, at that time, indicated it would assist if residents took the advice and voluntarily evacuated. Amoco had no responsibility with respect to mandatory evacuation.

1.28 Amoco's phone number was readily available to the public and complaints were recorded and investigated when made. Additionally, many Amoco employees reside, and are well known, in the area and were available to receive complaints and pass them on to the company.

1.29 During the early stages of the blowout, media briefings were not considered necessary. However, contacts by the media were responded to as soon as possible or as new information was available. During later stages, media briefings were held more frequently as a result of what Amoco perceived to be increasing concerns regarding health impacts and a tendency on the part of the media to sensationalize the event and mislead the public.

1.30 Amoco followed procedures throughout the blowout, such as diking drainage channels, to minimize the likelihood of condensate from the well getting into the Pembina River and other surface or groundwater systems.

1.31 Actions were implemented during the blowout phase to ensure the collection of sufficient information to measure impacts on the environment, including wildlife, and to support reclamation of the area.

1.32 The impact of H_2S on humans may be immediate death if levels reach as high as 1000 or 1500 ppm. Provincial air quality standards are set on the basis of avoiding nuisance impacts and are 0.01 ppm for a 1-hour period. Particularly sensitive persons may detect an odour at that level. The occupational health standard allows workers without breathing equipment to remain at work in concentrations of 10 ppm for 8 hours a day.

1.33 The monitoring for H_2S indicated peak readings for very short time periods of some 15 ppm in the general region of the well site that might be populated by the public (within 20 km). Beyond that, H_2S readings were very low, although the 0.01 ppm nuisance standard was probably exceeded about 3 per cent of the time for significant parts of the province.

1.34 The overall health of the public was not affected by emissions from the blowout. The extreme pungent odour of H_2S was a nuisance, causing discomfort and perhaps even vomiting in instances, but there were no long-term impacts of H_2S at the low levels experienced by the public.

1.35 Forest cover was destroyed and cleared in the 290 ha immediately adjacent to the 13-12 well. It was modestly affected by condensate to varying degrees over an additional 600 ha. The cleared area can be successfully reforested and the impacted areas beyond that will fully recover from the effects of the blowout.

The impact of H_2S and SO_2 on the forest cover was not great and much of it will be eliminated with time.

1.36 The substantial negative impact on soil was limited to some 40 ha with the most serious impact occurring only over about 16 ha. The productivity of most of these soils can be fully restored.

1.37 The effects of well effluents on surface waters was largely confined to the Pembina River and Zeta Creek and was limited in nature, although some slight seepage continues. The snow and some ice which was saturated with condensate was removed as soon as was practical. No lasting impacts on surface waters or on aquatic life are expected.

1.38 Impacts on wildlife were negligible. An evacuation and avoidance of the area occurred during the blowout and the period immediately thereafter. Wildlife can be expected to return to the area and certain species may be attracted to the cleared area during the period of reforestation in numbers greater than normal. Very few, if any, deaths among wildlife can be definitely attributed to the blowout and there is no evidence to suggest mutations have occurred.

1.39 Amoco was in the process of dealing with claims respecting alleged impacts on livestock, buildings, and equipment during the period of the inquiry, and thus it offered no views on these matters.

1.40 On the basis of information available up to the time of the inquiry, the well was likely blowing at a rate of some 1.4×10^6 m^3 per day and the gas probably contained 23 to 25 per cent H_2S and 750 m^3 of condensate per million cubic metres of gas.

2 Nabors Drilling Ltd. (Nabors)

The overall position of Nabors with respect to the blowout can be summarized as follows:

2.1 Nabors specializes in deep-hole drilling and its record in terms of safety and prevention of blowouts is excellent.

2.2 The rig met all 35 requirements of ERCB regulations and the rig workers exceeded normal training requirements.

2.3 Specific responsibility for types of equipment used and actions taken during periods when problems were occurring rested with Amoco, but Nabors had competent, experienced staff on site that consulted with Amoco on a continuous basis.

2.4 The blowout occurred as a result of a series of equipment failures described in detail by Amoco with the principal cause being the failure of the drill pipe.

2.5 The drilling crews were generally aware of the potential for H_2S gas in the area and were properly trained to deal with it.

2.6 The suitability of the drill pipe for sour gas service was not specifically considered by Nabors since it was the responsibility of Amoco.

2.7 BOP tests were conducted as required by the regulations, even though they were not all recorded in the daily drilling reports.

2.8 There were times during the night and morning of 16 and 17 October when operations were delayed due to lack of men. Even though there was the normal full complement of workers available, additional workers could have been used.

2.9 Procedures consistent with industry practice were used when dealing with the gas influx problems. Similar procedures and equipment, including details such as the iron oxide scavenger and the type of drill pipe, had been successfully employed during a sour gas kick on another well.

3 Staff of the Energy Resources Conservation Board (ERCB)

The position of the ERCB staff with respect to the blowout and subsequent events can be generally summarized as follows:

3.1 The licensee of a well which blows wild is normally allowed to retain responsibility for control of the well because of its familiarity with the area, and because the licensee usually has personnel and equipment readily available.

3.2 The drilling contractor's role in a major blowout is limited to assisting the well-control specialist where appropriate.

3.3 The ERCB may take control of the capping operations at a blowout, but this is not the normal practice. Where actual control is not taken, the ERCB staff role is to review and approve the control program, satisfy itself with respect to action taken to protect the public and the environment, properly secure the site, and liaise with other Government departments, the public, and media representatives.

3.4 The 13-12 well was properly licensed in accordance with existing legislation and practices. The rig was inspected and found to be satisfactory.

3.5 Amoco co-operated fully with the staff respecting control operations and its control plans were generally acceptable to the staff. The question of flaring the well to convert the H_2S to SO_2 was discussed with Amoco on several occasions, as was the possible drilling of a relief well. These matters were adequately considered by Amoco.

3.6 The monitoring program was the responsibility of Alberta Environment. The monitoring carried out was extensive and appeared sufficient to safeguard against serious impacts on the public. The staff were involved in establishing evacuation criteria, but the ERCB has no authority to order an evacuation.

3.7 Environmental controls and studies were adequate to minimize the impacts and to allow proper restoration.

3.8 Clean-up operations were properly carried out, but on-going work is required to accomplish complete rehabilitation.

3.9 There was not a detailed emergency plan requested for the 13-12 well because of its general remoteness from populated areas.

3.10 The one-window concept for contact between Amoco and Government departments appeared to work reasonably well. However, there were problems in co-ordinating efforts related to the media and in dealing with complaints and questions from the public. Additionally, clarification as to certain responsibilities, for example mandatory evacuation and contact with the media, is needed.

4 Government Departments

Six Government departments participated in the inquiry. They each presented witnesses and written evidence setting out their involvement in and views respecting the blowout. The overall position of each of the departments is summarized in the following:

4.1 Alberta Agriculture (AA)

The views of AA were based on visits to several farms in the area during the blowout, submissions to the provincial laboratory from the blowout area both during and following the incident, discussions at a series of public meetings, and visits with district agriculturists and veterinary practitioners in the area.

4.1.1 Damage to agricultural plants did not occur because they were not growing at the time of the blowout.

4.1.2 Disease conditions found in submissions to the laboratory could not be shown to be related to H_2S.

4.1.3 The pattern of diseases diagnosed by the laboratory from the area near the blowout was one that would normally be expected if the blowout had not occurred.

4.1.4 The number of aborted fetuses available for examination was insufficient for statistical evaluation, but no pattern that could be related to H_2S was detected.

4.1.5 Review of literature and air monitoring data indicates that the levels and duration of exposure of livestock to H_2S or SO_2 during the blowout would not have been expected to cause changes other than transient irritation to eyes and the respiratory system.

4.1.6 A study under way at the Vegreville laboratory indicates that there may have been transient but measurable effects from the emissions on enzymes in livestock. There is no conclusive evidence of irreversible changes and harmful effects are neither confirmed nor denied. Further work is needed.

4.1.7 Amoco is to file a more detailed livestock impact report with the department following the settling of claims.

4.1.8 Co-ordination of government and Amoco contacts by the ERCB was reasonable. A central contact group is a good idea, but technical questions should be referred to others for response.

4.2 Energy and Natural Resources (E&NR)

This department called witnesses from Alberta Forest Service (AFS) and Alberta Fish and Wildlife (AFW). Their positions respecting the blowout can be summarized as follows:

4.2.1 The operating company is responsible for containment, clean-up, and restoration of disturbed public forest land. During an emergency, the ERCB plays a co-ordinating role, but ensuring satisfactory clean-up and restoration is the responsibility of AFS.

4.2.2 An amended surface lease was granted to Amoco in February 1982. The approved surface location had been moved north of the Pembina River due to environmental concerns about drilling in an oxbow south of the river and because of a critical wildlife area.

4.2.3 The department was informed of the blowout on 17 October and representatives arrived in Drayton Valley on 18 October. A representative was either at Drayton Valley or in daily telephone contact with Drayton Valley thoughout the blowout.

4.2.4 Approval of activities to facilitate control of the well were given in a prompt and responsible manner. Examples of activities include clearing and construction of access roads, river and creek crossings, and drainage sumps, and removal and salvage of timber from the site.

4.2.5 If such a blowout was to occur in hot summer weather, it might have to be ignited because the unburned condensate collecting on trees would represent a fire hazard.

4.2.6 Short-term rehabilitation was commenced by Amoco under direction from AFS immediately following the blowout. All trees more than 50 per cent covered with condensate were cleared (some 290 ha). Levelling and seeding to grass was done and seedlings were obtained for reforestation to begin in 1984.

4.2.7 Planning for long-term rehabilitation is under way and successful reclamation can be expected.

4.2.8 There is no evidence of significant impact on fish or wildlife from the blowout.

4.2.9 The one-window approach involving the ERCB as the main Amoco contact functioned well but a central command post was needed to co-ordinate government activities during the emergency and to communicate with the public. The concept of a response team might include public input.

4.3 Workers' Health, Safety and Compensation

The Occupational Health and Safety Division (OH&S) of this department presented evidence regarding its involvement in and views of the blowout. Its position can be summarized as follows:

4.3.1 The relevant responsibility of the division is to attempt to prevent workplace injuries and illnesses through regulation, promotion, inspection, and investigation.

4.3.2 The division learned of the blowout on 18 October and was in telephone contact with Amoco. An inspector was dispatched to the area on 20 October and spent considerable time in the area throughout the period of the blowout.

4.3.3 Representatives of the division attended many safety and planning meetings and inspected safety equipment. The planning procedures and equipment were generally found acceptable and no contraventions of legislation or regulations were detected.

4.3.4 There was discussion on 21 October of igniting the well to provide a safer environment for workers. Nothing further was done because the capping was expected to take only a few days. An assessment is needed of the relative safety risks of capping a well burning as opposed to not burning.

4.3.5 Following an accident on 16 November and subsequent meetings on 17 and 18 November, the division required the use of positive pressure-type breathing apparatuses rather than the demand-type which had been previously used. A mask-up requirement at 20 ppm of H_2S was also imposed to replace an earlier practice of masking up at 50 ppm.

4.3.6 Medical representatives from the division were involved with Amoco in formulating a co-operative follow-up health study of workers involved on the blowout site.

4.3.7 The OH&S standards for H_2S are an average of 10 ppm for 8 hours, 15 ppm for 15 minutes, and a maximum of 20 ppm as the mask-up ceiling. For SO_2, the standard for workers is an average of 2 ppm for 8 hours, 5 ppm for 15 minutes, and a 20-ppm ceiling. For both H_2S and SO_2, the 8-hour standards include the additional proviso that there must be a minimum 60-minute interval between each exposure and no more than four exposures per day.

4.3.8 The ERCB's co-ordination of company and government involvement was acceptable, but a better means of communication with the public is needed.

4.4 Alberta Disaster Services (ADS)

The position taken by ADS respecting the blowout is summarized in the following:

4.4.1 ADS co-ordinates, advises, and trains respecting emergency planning in the province.

4.4.2 ADS learned of the blowout on 17 October, made many visits to the area while it was uncontrolled, and was in general contact with Amoco, other Government departments, involved local authorities, and other agencies for the duration of the incident.

4.4.3 An Order in Council or a declaration by a local authority is required for a "state of emergency" to exist, which in turn allows mandatory evacuation of citizens. A state of emergency was not declared because Amoco, local and other authorities, and involved Government departments or agencies were handling the situation in an acceptable manner. Voluntary evacuation is usually very effective and, to the limited extent needed, was in this case with Amoco playing a lead role.

4.4.4 The one-window concept for government-Amoco contact with the ERCB as a co-ordinator worked reasonably well, but better communications with the public, perhaps including paid announcements, were needed to overcome misinterpretation of the situation. Co-ordination does not mean one group has control over others, but rather that information is exchanged, and this took place.

4.5 Social Services and Community Health (SS&CH) and the Provincial Board of Health (PBOH)

SS&CH has close ties with the PBOH, both in terms of responsibilities and key personnel. The Deputy Minister of SS&CH is, by virtue of the office, the Chairman of the PBOH. The action taken and positions of these organizations with respect to the blowout is summarized in the following:

4.5.1 In the early stages of the blowout, discussions took place to ensure that the necessary actions were being carried out. These included efforts to control the well and appropriate monitoring. As it became clear that the well was not being controlled as quickly as expected, the PBOH began a co-ordination role in terms of possible health impacts.

4.5.2 A 24-hour complaint line was established. Of a total of 1477 complaints, 491 health-related complaints, with 31 different symptoms, were received. The frequency of complaints received was not always consistent with the H_2S levels which were being monitored.

4.5.3 Discussions with other involved parties took place respecting the gathering of relevant data, studies of health effects of H_2S, the holding of seminars on H_2S, the development of evacuation criteria, and public relations aspects of sour gas blowouts.

4.5.4 A committee established a list of health-related questions and recommended the development of a systemized research plan to scientifically address them. The PBOH endorsed that approach, but delayed further action pending the outcome of the subject ERCB inquiry.

4.5.5 A committee prepared an information brochure on H_2S to be made available to the public. Evacuation criteria and advice to the public as to actions that should be taken in the event of exposure to H_2S were included in the brochure.

4.5.6 The design of a study on pregnancies in the Lodgepole area was commissioned. Dr. Love, who carried out the work, concluded that a proper study was not possible because an adequate number of H_2S level readings did not exist, the recorded levels of H_2S were so low that impacts would not be expected, there were only a small number of pregnancies in the area at the time, and a rubella epidemic was having an impact on the spontaneous abortion rate.

4.5.7 No significant health hazard existed for the general public, but it is recognized that there is not sufficient research data available to clearly determine whether health impacts can occur as a result of low-level, long-term exposure to H_2S. Similarly, data does not show that respiratory patients are more susceptible to tissue damage from H_2S, but studies of actual situations suggest that they likely are.

4.5.8 Better effort could and should have been made to see that the proper information respecting the Lodgepole blowout was being provided to the general public.

4.5.9 The PBOH should be involved in the setting of evacuation limits and in decisions respecting the intentional ignition of sour gas blowouts. Special evacuation levels may be required for sensitive individuals.

4.6 Alberta Environment (AE)

The evidence presented to the inquiry by AE is summarized in the following:

4.6.1 The responsibility of AE in the case of a blowout is to protect the environment. The department does not have a direct responsibility in terms of controlling the blowout, but its advice and direction may affect the manner in which the well will ultimately be controlled. In the particular instance of the Lodgepole blowout, AE was involved in discussions on a regular basis with respect to intentionally igniting the well during much of the relevant period of the blowout.

4.6.2 The one-window concept with the ERCB being the main contact with the operator worked effectively in the case of the Lodgepole blowout and should generally be retained. Communications with the public, however, left something to be desired. A follow-up survey by AE respecting the notification of emergency that took place in Cynthia revealed that the process would have been more effective if it was better organized and if the residents contacted had been given better information.

4.6.3 AE conducted a portion of the monitoring which took place and also co-ordinated all of the monitoring, including that carried out by Amoco and the ERCB. AE has a philosophy that the operator should have monitoring responsibilities which includes paying for its own monitoring units. The number of units needed is dependent on each particular situation and, in this case, was sufficient to ensure safety of the public.

4.6.4 The highest recorded levels of H_2S were in the order of 30 ppm away from populated areas. Twenty-three ppm was the highest recorded level at residences and 14.5 ppm was the highest level recorded in communities. The highest SO_2 reading recorded was 0.275 ppm near Edson.

4.6.5 AE had understood throughout the duration of the blowout that if concentrations of H_2S reached 20 ppm at Drayton Valley, the well would be ignited.

4.6.6 The deposition rates for sulphur, as calculated by Monenco Consultants Limited (Monenco) in a submission made on behalf of the Public Advisory Committee of the Environment Council of Alberta, were inaccurate and much too high.

4.6.7 There is no evidence of significant or lasting impact on the environment, other than for the immediately surrounding area of the 13-12 well where condensate saturation took place and the trees were ultimately removed. It is anticipated that reforestation of this area can be successfully accomplished.

4.6.8 An emergency response plan should be in place where sour gas blowouts might occur and it should be the responsibility of the operator preparing the plan to include the name and the location of residents within the area which could be significantly affected by a blowout.

4.6.9 The experience gained during the 13-12 blowout led to the following recommendations:

(a) a system is required which will make available accurate flow information at the outset of a blowout,

(b) a review should be made of the industry's ability to respond quickly to extensive monitoring requirements,

(c) the composition of all possible gaseous emissions from Alberta oil and gas pools should be determined,

(d) AE should be given full control of off-site monitoring during sour gas blowouts,

(e) communications with the public respecting blowouts must be greatly improved, and

(f) criteria for the firing of sour gas wells should be made part of the well licence.

5 The Public Advisory Committee of the Environment Council of Alberta (PAC)

Representatives of Monenco appeared on behalf of PAC and presented the results of an environmental investigation. A representative of PAC also presented certain recommendations that arose as a result of the blowout. The evidence can be summarized as follows:

5.1 Sulphur deposition as a result of the blowout amounted to some 15 to 35 kg/ha over a very large area of some 1400 square kilometres. This gives reason for concern even though it is not known whether negative impacts such as soil acidification resulted from this deposition.

5.2 Some 1950 ha immediately surrounding the wellbore were visibly affected due to deposition of alkaline formation water. Some 270 ha experienced some damage as a result of condensate and some 37 ha were totally saturated with condensate. There is no real evidence available to support the conclusion that complete reforestation will be possible.

5.3 Sufficient concern has arisen as a result of the blowout and the following investigation to raise serious questions as to whether lasting environmental impacts occurred. Should there be similar blowouts in the future, environmental data should be collected from the outset and major environmental impact studies should be initiated as soon as possible.

5.4 There appeared to be confusion throughout the 13-12 blowout as to which Government department or agency had the co-ordinating role with respect to the environment.

5.5 In the case of sour gas blowouts, government officials should take charge of and carry out all of the monitoring to ensure that the data is available to the public and that it has credibility. The operator could be held financially responsible for the monitoring, but should not play a direct role in it.

5.6 A medical protocol should be put in place so that data could be immediately gathered and studies commenced if a future sour gas blowout occurs.

5.7 Government representatives should have the responsiblity of deciding when evacuation is necessary and of directing it, except for the immediate response if an emergency exists within a few hours of a blowout, during which time the operator would be expected to act.

5.8 AE should be responsible for gathering the necessary data and commissioning or carrying out the necessary studies to determine if serious environmental impacts have occurred.

6 Pembina Area Sour Gas Exposures Committee (PASGEC)

PASGEC produced a large number of witnesses, most of whom are residents of the general area. The witnesses described to the panel the situation as they perceived it during the blowout. PASGEC also commissioned a survey which was conducted by WIN Consulting Corporation Ltd. The evidence put forward on behalf of PASGEC is summarized in the following:

6.1 PASGEC is not anti-industry, but merely wished to put its views forward and to receive answers to a number of questions.

6.2 Since the government and Amoco appeared evasive when contacted during the blowout, and since Amoco had experienced a previous blowout in the area, PASGEC reached the general conclusion that the incident could have been avoided.

6.3 Insufficient information was made available to the public, particularly with respect to monitoring results. PASGEC questioned whether an adequate number of monitors were available, whether the instrument ranges were adequate, and whether organization and co-ordination of the monitoring was appropriate.

6.4 Most people in the area were never contacted and, unless they phoned, never heard from Amoco, the ERCB, or Government departments. In some instances, even upon phoning, they received what appeared to be a runaround. Little information was made available regarding the willingness or otherwise of Amoco to evacuate persons from the area.

6.5 Individual monitoring equipment, such as Drager tubes, should have been distributed to the general population in the area. Additionally, a booklet or some other form of information and advice respecting H_2S should have been made available.

6.6 Some three-quarters of the people surveyed believed they experienced symptoms from H_2S and some 60 per cent were of the view that the blowout could have been prevented. Almost all individuals surveyed considered that a poor job had been done by Amoco, the ERCB, and Government departments in providing information to the public.

6.7 Certain individuals who reside in the area and have respiratory problems experienced extreme difficulties during the blowout. These individuals should have been evacuated at the outset of the incident.

6.8 Many individuals experienced one or more symptoms such as burning eyes, headaches, sore throats, chest pains, breathing difficulties, coughs, stomach cramps, gas pains, nausea, listlessness, or insomnia.

6.9 Animals experienced runny eyes, coughing spells, scours, and general weight loss. Calves born in the spring following the blowout were smaller than normal and did not gain weight as would be expected. Spontaneous abortions among livestock appeared to be somewhat higher than normal.

6.10 Birds and small animals seemed to disappear from the area and were slow to return.

6.11 Silverware, jewellry, and other ornaments or china discoloured during the blowout, and houseplants generally died.

6.12 Paint peeled off of many buildings, and machines and fences seemed to rust more rapidly than normal.

6.13 Many individuals found that discomforts occurred even while the well was on fire. Consequently, there was not unanimity that a sour gas well should automatically be fired if it blows out. Most of the participants from the public indicated that the important thing was to prevent blowouts wherever feasible and, where they did occur, to ensure that they were controlled as soon as possible.

7 Canadian Institute of Public Health Inspectors (CIPHI)

CIPHI, through Dr. Greenwood, a consultant, took the following position respecting the blowout:

7.1 Bureaucratic organizations are typically able to handle routine events on the basis of prearranged plans, but are not readily able to handle non-routine events.

7.2 With respect to the 13-12 blowout, there was a lack of clarity in responsibility and co-ordination between various involved parties, particularly Government departments.

7.3 There was insufficient information available as to the residences of persons who might have needed evacuation. This is a deficiency that must be resolved in the event of future similar blowouts.

7.4 A task force, with a clearly designated leader, should be in place to handle future blowouts. The task force should have the authority to prescribe evacuation levels and to take actions such as requiring the immediate firing of the well.

8 Edmonton Area Respiratory Patients (EARP)

This group was formed as a result of the blowout and is made up of individuals in the Edmonton area that suffer from serious respiratory problems. Many of them are fully hospitalized and others are out-patients. The views they expressed at the inquiry may be summarized as follows:

8.1 Some 20.53 per cent of all Canadians have respiratory problems and are thus more susceptible to pollutants. EARP represents a good cross-section in terms of the various respiratory ailments.

8.2 The patients believed they experienced more breathing and similar problems during the blowout than in the same period in other years. This was confirmed by a chart study for 32 in-patients and 28 out-patients which generally indicated greater problems during the blowout than immediately before or after it.

8.3 More scientific research is needed, particularly with respect to long-term exposure to low levels of H_2S, impact of H_2S on sensitive individuals including respiratory patients and young or old, and the interaction of H_2S and other chemicals. Some of this research could be facilitated by concentrating on individuals who work in H_2S environments or live in communities where low-level concentrations frequently occur.

8.4 The World Health Organization's definition of health refers to the "well being" of individuals. The odours resulting from the blowout certainly affected the well being of some individuals, in some cases to the extent of causing nausea.

8.5 If similar blowouts occur in future, a control centre should be established for co-ordination of activities and communications with the public. There should also be a pollution response team formed to adequately monitor for pollutants and the results should be made available to the public.

9 Health Unit Association of Alberta

This group did not present evidence, but in the closing argument took the following position:

9.1 The Medical Officer of Health and local health authorities should be involved in planning for emergencies such as the Lodgepole blowout and their jurisdictional responsibilities should be more clearly defined.

9.2 A protocol should be established and financial support should be made available so that health data gathering and research work could commence immediately when future blowouts occur.

10 Alberta West Central Health Unit (Health Unit)

Dr. Bayliss presented the following evidence on behalf of the Health Unit:

10.1 The Health Unit was aware of the blowout within a day of its occurrence and was in daily contact with the ERCB and other involved parties.

10.2 The question of intentionally igniting the well was discussed as early as 19 October 1982. The understanding was that the well would have been ignited if evacuation levels were encountered at Drayton Valley.

10.3 Medical clinics were held at Drayton Valley and Lodgepole during the period of the blowout. Certain physicians in the general area suggested that any H_2S health impacts resulting from the blowout were below irreversible levels.

10.4 Better co-ordination of responsibilities is needed in the case of future blowouts. In particular, improved information for the public is an absolute requirement.

11 Environmental Law Centre (ELC)

The ELC did not present evidence, but cross-examined certain witnesses and participated in closing argument. The position taken by the ELC is summarized as follows:

11.1 The inquiry procedure revealed two critical areas of confusion: the first being jurisdiction over environmental matters and human health, the second being responsibility for emergency response planning and actions.

11.2 Most of the environmental studies were conducted by Amoco rather than Government departments and this results in lack of credibility.

11.3 A review is needed of the framework of environmental responsibilities and services in the province.

11.4 Funds should be made available to study the long-term, low-level effects of H_2S.

11.5 Evacuation criteria should be firmly established and up-to-date records of where people live are necessary as part of an emergency response plan when sour gas wells are being drilled.

12 Mr. C. Sams

Mr. Sams is a former long-term oil-field worker with considerable experience on drilling rigs, at responsibility levels up to and including the position of "driller". In this capacity, he would operate the rotary drilling equipment and have direct responsibility for a crew of three to five workers. Mr. Sams' position respecting the blowout can be summarized as follows:

12.1 The drilling industry generally has not taken sufficient precautions respecting the safety of workers.

12.2 OH&S does not have sufficiently trained people to properly understand and adequately inspect drilling rigs.

12.3 Drilling rig crews are often not sufficiently trained in kick-control and blowout prevention procedures to adequately deal with them.

12.4 The ERCB inspection frequency for rigs is not sufficient, nor is the detail of the inspections. Additionally, rigs should be inspected without prior warning and during the night and weekends as well as normal working weekday hours.

12.5 The personnel on the rig did not react properly in every respect when the problems were encountered on the evening of 16 October and morning of 17 October. Better attention to and knowledge of the drilling records (eg, geolograph charts), the mud system, kick-control procedures, and procedures for tying down drill pipe to prevent it being forced out of the hole could have prevented the blowout.

12.6 The inquiry did not receive sufficiently detailed information to understand the cause of the blowout.

13 Other Involved Organizations

Inquiry Counsel, on behalf of the Panel, called witnesses from several organizations that had involvement in the incident but which had not registered as participants. These included the Town of Drayton Valley, the County of Parkland, and the Royal Canadian Mounted Police (RCMP). Their respective positions are set out in the following:

13.1 Town of Drayton Valley (Town)

13.1.1 The Town could have, if necessary, declared an emergency within minutes. This was not considered necessary as Town officials did not believe the situation such that an emergency evacuation would be needed. For this reason, residents were not informed of a possible need for evacuation.

13.1.2 Amoco and local Government departments appeared to be addressing the matter in a satisfactory manner and kept Town officials reasonably aware of the situation. Two monitors within the town were installed by Amoco to ensure that H_2S concentration levels were known and could be reacted to as appropriate.

13.1.3 Daily news releases describing the up-to-date situation should have been issued by Amoco and the ERCB.

13.2 County of Parkland (County)

13.2.1 The County was not satisfied with the degree of co-ordination. It should have been involved at the outset and kept up to date.

13.2.2 The public should have been made aware of any evacuation plans that existed.

13.2.3 The County is a knowledgeable party without a vested interest in the 13-12 blowout and, as such, could have provided information to the public in a credible manner.

13.3 Royal Canadian Mounted Police (RCMP)

13.3.1 The RCMP learned of the blowout from the ERCB on 17 October.

13.3.2 An appropriate arrangement existed between Amoco and the RCMP regarding notification and evacuation of the public. The RCMP assisted in the notification of Lodgepole residents on 18 October and would have been available to do the same for the town of Cynthia if requested.

13.3.3 Road-blocks to prohibit entry by the public to the well-site area were set up and manned by the RCMP or Amoco through an arrangement agreed to by the police.

13.3.4 The co-ordination of the incident was generally acceptable, but better communication with the public should have taken place.

14 The General Public

Informal sessions of the inquiry were held in both Drayton Valley and Edmonton to allow members of the general public to express their views regarding the blowout. The number of individuals that came forward to express their views was limited and the following is a summary of the positions they took:

14.1 Many individuals experienced health symptoms during the blowout, many youngsters were absent from school, and missed work-time appeared to be greater than normal. Had the inquiry taken place closer to the time of the blowout, more people would likely have appeared.

14.2 Animals suffered from runny eyes, breathing problems, and scours, and generally experienced weight losses during the period of the blowout.

14.3 Government should be doing the monitoring, not the oil company, and the government must keep the public informed. For example, the public should have been given reasons as to why the well was not intentionally ignited. The ERCB must take steps to see that similar instances do not occur in future.

APPENDIX 5 LODGEPOLE BLOWOUT INQUIRY — PHASE 2 REPORT

Decision D 84-5

Lodgepole Blowout Inquiry — Phase 2.

Sour Gas Well Blowouts in Alberta;
Their Causes, and Actions Required to
Minimize Their Occurrence

Issued 25 April 1984

ENERGY RESOURCES CONSERVATION BOARD

Calgary Alberta

LODGEPOLE BLOWOUT INQUIRY — PHASE 2. SOUR GAS WELL BLOWOUTS IN ALBERTA; THEIR CAUSES, AND ACTIONS REQUIRED TO MINIMIZE THEIR FUTURE OCCURRENCE

Decision D 84-5
Proceeding 830007

1 EXECUTIVE SUMMARY

The inquiry into the Lodgepole blowout[1] was undertaken in two phases; Phase 1 being an inquiry into the causes and impacts of the blowout of the AMOCO DOME BRAZEAU RIVER 13-12-48-12 well (13-12 well), and Phase 2 being an inquiry into improvements that might be made in drilling operations in order to reduce the possibility of another such blowout occurring in Alberta.

Several important recommendations were made during the second phase of the inquiry and the Inquiry Panel (Panel) is convinced that while the Alberta blowout record is comparable to that in other jurisdictions, it can be improved. Furthermore, because drilling is on-going, the Panel believes that improvements should be instituted as quickly as possible to reduce immediately the potential for another "Lodgepole". It has, therefore, decided to complete and publish its report on the second phase of the inquiry prior to the completion of its report on the causes and impacts of the blowout of the 13-12 well.

Participation in Phase 2 of the inquiry included representatives from oil and gas industry associations, and several major companies. There was also limited participation from the general public and the Alberta government.

The Panel has reviewed all of the recommendations made and believes that many of them can assist in reducing the number of blowouts in Alberta, particularly blowouts of sour gas wells. While some of the recommendations can only be implemented after research and review, several can be initiated immediately and the Panel has so recommended.

Almost everyone appearing at the second phase of the inquiry agreed that the primary cause of blowouts is human error and the remedy is to reduce that possibility. Immediate steps should be taken, therefore, to improve and increase training and awareness of the potential contributory factors by *all persons* associated with drilling operations. The blowout prevention process must begin with the initial plans for drilling the well and must include the equipment to be used and the special precautions to be taken. All parties must support an improved and comprehensive inspection process to ensure that the equipment, planning, and its execution are fully effective.

The Panel has asked the ERCB to implement, as a priority, a program which will impose additional controls in the planning for and drilling of certain critical sour wells. For such wells, the drilling plan and equipment to be used will require ERCB approval. An emergency response plan will also be required.

A review committee will also be formed to identify measures to improve training and awareness with respect to drilling and to improve the planning for, and equipment used in drilling into formations where high pressure hydrogen sulphide (H_2S) gas may be encountered. Human error as a factor in drilling operations will be reviewed to determine what actions to reduce it are feasible. The inspection of drilling rigs will be addressed by the committee with a view to increased inspections prior to critical drilling operations, and the potential for the development of an Alberta code of practice for drilling will be examined.

Some activities are already underway and others will be implemented following the release of this report. Time limits for reporting to the ERCB by the review committee have been set to ensure that results are obtained respecting the improvements required. These findings and others are more specifically described in Section 6 of the report.

The Panel expects that implementing the recommendations arising out of Phase 2 of the Lodgepole Inquiry will lead to improved oil and gas well drilling practices in Alberta which will reduce the number of well blowouts, especially sour well blowouts.

2 INTRODUCTION

2.1 Background

The well, AMOCO DOME BRAZEAU RIVER 13-12-48-12, located in legal subdivision 13 of section 12, township 48, range 12, west of the 5th meridian, near the hamlet of Lodgepole, Alberta, blew out of control from 17 October 1982 to 23 December 1982 — a total of 67 days. On 14 January

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[1] A glossary of oilfield terms is attached as Appendix 1.

1983, the Energy Resources Conservation Board (ERCB) announced that an inquiry would be held ". . . to determine the facts surrounding the Lodgepole gas well blowout . . .". Three pre-inquiry meetings were held to establish terms of reference and other details of how the inquiry should proceed. The terms of reference were issued on 5 May 1983. The inquiry was separated into two phases — the first to deal specifically with the blowout of the 13-12 well and the second

> ". . . to inquire into, report upon, and make such recommendations as are necessary or advisable in relation to the causative factors of sour gas blowouts in Alberta and actions that can be reasonably taken to minimize the possibility of future occurrences."

This report pertains to Phase 2 of the inquiry.

2.2 Procedural Decisions

The inquiry was separated into two phases in order to facilitate industry participation in that portion of the inquiry dealing with the broad question of blowouts in the Province as a whole. For the same reason, the Panel agreed to move the venue for Phase 2 from Drayton Valley to Calgary. It was also decided to conduct separate registrations of participants for Phase 1 and Phase 2, to hold separate final arguments, and to issue separate reports. The Panel also decided there would be one continuous record for both phases of the inquiry and as a result, evidence filed and heard in Phase 1 would, where appropriate, apply to Phase 2, and vice versa.

2.3 The Inquiry

The Panel consisted of V. Millard, Inquiry Panel Chairman, and Panel Members, G. J. DeSorcy, P.Eng., F. A. Herbert, M.D., J. W. Markham, M.B., N. A. Strom, P.Eng., and R. S. Weaver, Ph.D. Participants in the inquiry are listed in Appendix 2.

Phase 1 of the inquiry was held from 1 November 1983 to 15 February 1984 in the town of Drayton Valley, Alberta, except for one day in Edmonton, Alberta, on 9 December 1984. Phase 2 was held from 20 February 1984 to 2 March 1984 in Calgary, Alberta.

2.4 Sour Gas Wells in Alberta

Early in 1983, the Panel commissioned F. G. Bercha and Associates Limited to analyse the risk of sour gas drilling blowouts in Alberta. Bercha found that the number of sour gas wells drilled in Alberta was too low to permit meaningful statistical study as a separate group. Bercha found that approximately 1 per cent of the 20 000 wells drilled in the three years 1980 to 1982 were sour.

In separate evidence, the ERCB staff testified that of the 220 sour wells drilled in 1980-1982, 160 were classified as sour oil wells and 60 as sour gas wells. Of the 60 sour gas wells only 25 produce gas containing more than 1 per cent H_2S.

Bercha found it necessary to analyse the data for all wells, whether sweet or sour, oil or gas, and then modify its findings to reflect the frequency of occurrence of H_2S. Bercha made no distinction between oil and gas wells.

3 WELL BLOWOUTS IN ALBERTA

3.1 Risk of Blowouts

Blowouts occur as a result of a failure to control a "kick". Based on a review of the ERCB's computer records and document files, Bercha found that of the 4000 to 6000 wells drilled each year in Alberta

- 1 in every 29 (3.5×10^{-2}) would experience one or more kicks,
- 1 in every 2900 (3.5×10^{-4}) would experience a blowout, and
- 1 in every 62 500 (1.6×10^{-5}) would be a sour gas well blowout.

The above estimate of the sour gas well blowout rate is based on the proportion of sour wells in the total number of wells drilled and the assumption that sour wells are no more difficult to drill than sweet wells. However, the Panel has reviewed the ERCB data and found that 6 sour gas well blowouts were experienced while drilling 51 000 wells from 1974 to 1983. This is 1 in every 8500 (1.2×10^{-4}). The total number of sour gas wells drilled was 1030; therefore, the rate of sour gas well blowouts per sour gas wells drilled is 1 in every 172 (5.8×10^{-3}).

Bercha testified that the higher blowout rate actually experienced for sour gas wells is the result of a number of factors:

- sour gas is highly corrosive and equipment failures are more likely in the presence of sour gas,
- in any potentially sour environment, blowout prevention procedures are complicated by the need for drilling crews to take greater precautions, and
- deeper wells, whether sweet or sour, experience a much greater rate of drilling problems, and sour gas is found only in the deeper formations.

From the ERCB's records of the wells drilled in the period 1980-82, Bercha was able to relate the occurrence of a kick (ie, the first stage of a potential blowout) to the drilling operation in progress. He found that the 703 kicks reported occurred

40 per cent while tripping out,
33 per cent while drilling,
13 per cent while circulating,

7 per cent while tripping in,
3 per cent while coring,
2 per cent while testing, and
2 per cent while other operations were in progress.

A brief description of the blowouts in the last 10 years is provided in Appendix 3.

A review of the circumstances leading to these blowouts reveals that they occurred

43 per cent while tripping out,
33 per cent while drilling,
10 per cent while running casing,
5 per cent while circulating,
5 per cent while logging, and
5 per cent while coring.

These findings are very similar to those reported by Bercha, even though they are for blowouts rather than kicks, are for a different time period, and are for a much smaller number of occurrences.

3.2 Cost of Blowouts

Confer Consulting Ltd. was engaged by the Panel to develop estimates of the costs associated with blowouts for a range of consequences identified as minor, moderate, and severe. These were to reflect the consequences defined as sour gas well blowouts lasting 1 day, 6 days, and 100 days, respectively. Equipment losses and other consequences were assumed to escalate progressively with the duration of the blowout.

Confer estimated that the cost of a severe sour gas well blowout could be 50 million dollars, of which one half would be the cost of lost, delayed, or deteriorated hydrocarbon production. A moderate blowout could cost 2 million dollars, of which 0.5 million dollars was associated with hydrocarbon losses. A minor blowout could cost less than 200 thousand dollars with negligible hydrocarbon losses.

It should be noted that these costs do not include many intangible and unquantifiable social costs such as nuisance impacts and the feelings of anxiety on the part of the general public.

With potential costs of the magnitude estimated above, the Panel believes certain measures to reduce blowouts are justified, particularly for sori wells where the impacts would be greatest. For instance, the Panel believes it would be beneficial for industry to direct funds into research concerning equipment and materials on a continuous basis and to support efforts to reduce blowouts.

3.3 Alberta Drilling Performance

3.3.1 Blowout History

The frequency of well blowouts in Alberta for the past 25 years is presented in Figures 1 and 2. Figure 1 shows the number of wells drilled and the number of blowouts. Figure 2 shows a 3-year moving average of the number of blowouts per well drilled. It reveals a low in the number of blowouts per well drilled in 1963, a rapid rise to a peak in 1969, followed by a decline to the present time. No evidence was heard to explain the marked variation in the blowout rate in the 1960s, however, the Panel is aware that the Pembina-Cardium area was drilled in the late 1950s and early 1960s, and it is a low permeability sweet oil pool which would not likely result in blowouts. In contrast, the Zama-Keg River area of northwest Alberta was drilled in the late 1960s, and it is an area prone to lost circulation and other drilling problems.

The blowout rate dropped substantially in the early 1970s and has further declined in recent years to one blowout for every 2900 wells drilled (a rate of 3.5×10^{-4}). Several participants credited the decline to improved equipment and improved training of rig personnel. CAODC noted that the first complete blowout prevention course designed by industry was presented in 1968. In 1971, well control training facilities were established at Golden Spike.

3.3.2 Comparison to Other Jurisdictions

Many of the witnesses who appeared in Phase 2 had drilling experience in other parts of the world — either in other provincial or federal jurisdictions within Canada or in other countries. Although they provided no details, the majority of witnesses examined on this subject said they believed Alberta's blowout record was comparable to that in other jurisdictions.

Bercha testified that, on the basis of other blowout studies it had done and the literature it had reviewed, Alberta's recent blowout rate of 3.5×10^{-4} was remarkably close to the estimated world average of 3.9×10^{-4} for land-based wells.

3.3.3 Rig Inspections

Drilling equipment is inspected separately and regularly by operators, contractors, and ERCB staff. Current regulations do not require operators or contractors to file their inspection reports with the ERCB. The matter of rig inspections is dealt with further in Appendix 4.

ERCB staff testified that inspections of drilling rigs had been carried out by its staff on 33 per cent of all wells drilled during the years 1979 to 1983. The staff found that 47 per cent of the rigs inspected were unsatisfactory in some respect. Of the 47 per cent found unsatisfactory, 83 per cent had one or more serious deficiencies. A serious deficiency was

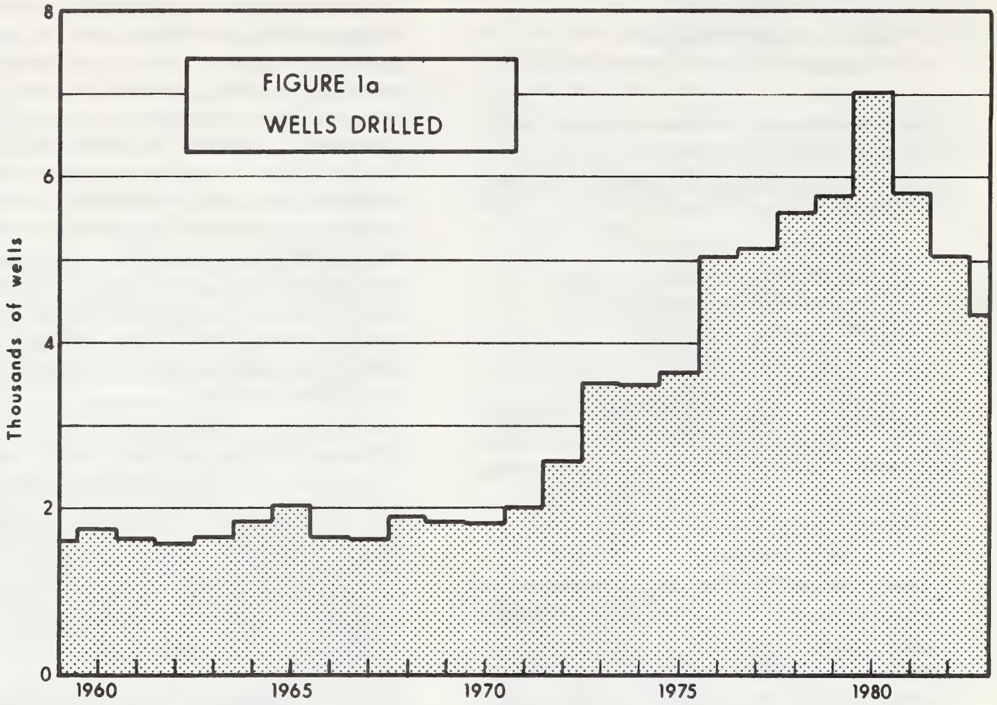

FIGURE 1a
WELLS DRILLED

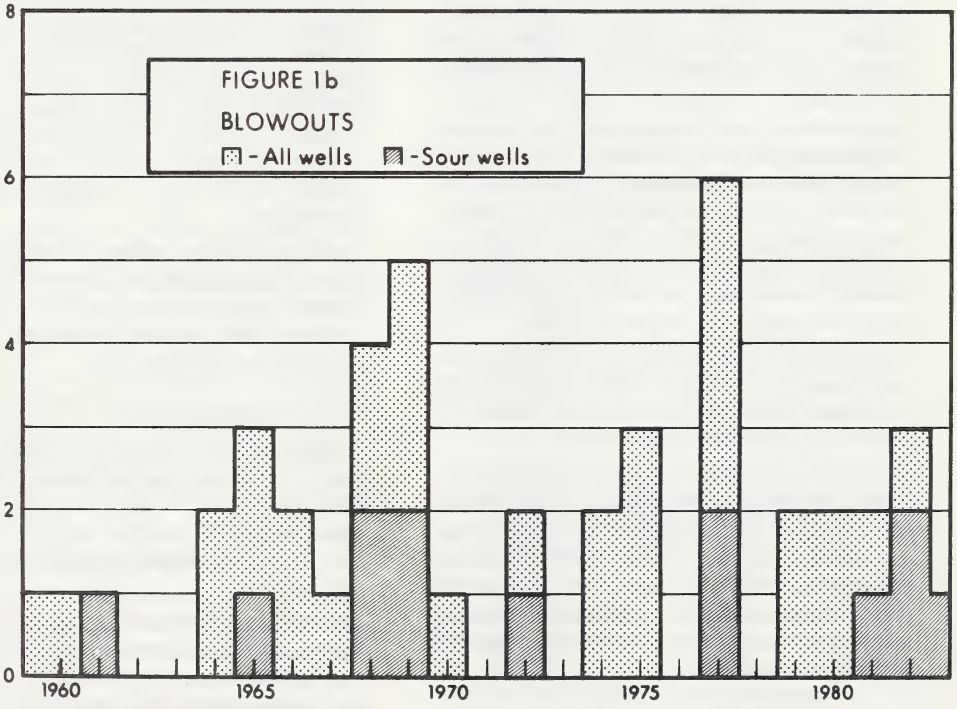

FIGURE 1b
BLOWOUTS

▨ - All wells ▨ - Sour wells

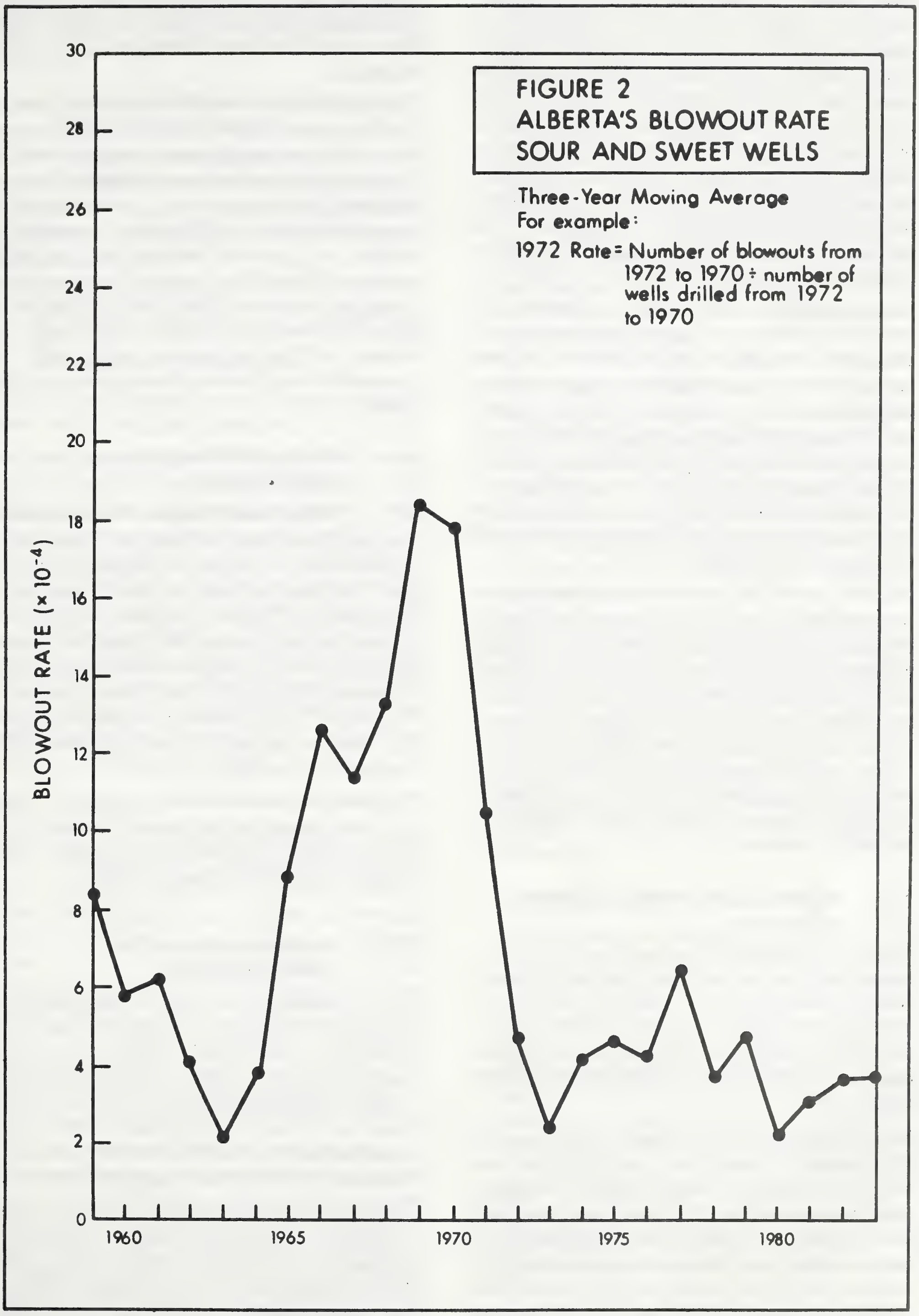

FIGURE 2
ALBERTA'S BLOWOUT RATE
SOUR AND SWEET WELLS

Three-Year Moving Average
For example:
1972 Rate = Number of blowouts from 1972 to 1970 ÷ number of wells drilled from 1972 to 1970

described as a matter that might hinder well control under certain circumstances. One of the circumstances that would have to exist in order for the serious deficiency to represent an immediate danger is that the rig would have to be drilling in or approaching a porous formation where a flow of fluid into the wellbore would be possible. Indeed, only 4 per cent of the rigs found unsatisfactory were judged to be in immediate danger to the extent that they were immediately shut down and further drilling progress prohibited until the deficiency was rectified. A further 16 per cent required immediate correction but were not shut down.

Serious concern was expressed as to whether the ERCB staff definition of serious deficiencies was appropriate. The ERCB staff emphasized that the definitions had been developed to direct its available inspection staff to new rigs, rigs with poorer records, and those in trouble prone areas, and not for the purpose of measuring the overall adequacy of rigs. The staff suggested that it and industry representatives should review the definitions and inspection data and prepare a new set of statistics which would reflect overall rig adequacy.

The Panel agrees this should be done and has so recommended to the ERCB. A committee is being appointed by it, including a representative on behalf of the public, and a report, which will be made public, is expected within two months. The committee is being asked to review the adequacy of inspection coverage, not only by the ERCB but also by industry, and to recommend ways in which the inspections and resulting reports could be better co-ordinated. The letter inviting participation on the committee is attached as Appendix 4.

3.4 Scope for Improvement in Incidence of Blowouts

Figure 2 illustrates that there has been a wide variation in well blowout rates over the last 25 years. Although most participants stated they believed an irreducible minimum existed because the basic problem is human error, none suggested that the low rate experienced in the last few years could not be reduced further.

Bercha concluded that all blowouts were the result of the failure to control a kick, and that failure was most often the result of human error. Several of the other participants agreed that human error was often involved, but many believed that a combination of human errors and other factors (eg, equipment failure, weather conditions, unpredictable geological conditions) played a combined role in causing blowouts. Bercha concluded that the greatest potential for reducing the blowout rate was by increased enforcement of the drilling regulations, followed by improved training of drilling personnel. While some participants agreed with Bercha, the majority stated they believed improved training would be the most beneficial.

The Panel concludes that the frequency of blowouts can be reduced further and in view of the much higher blowout rate for sour wells, believes that emphasis should be placed on that category. However, because of the human factor it is unreasonable to expect elimination of all blowouts. Improving the training of all persons involved with the drilling operation will most likely reduce blowouts and adjustments must be made to other factors that contribute. Since the potential for blowouts will always exist, industry will have to maintain its vigilance. The Panel will be be addressing these matters later in the report.

4 RECOMMENDATIONS BY PARTICIPANTS

4.1 Primary and Secondary Recommendations

The participants presented many recommendations and there was considerable agreement on most of these. The Panel has classified some of these recommendations as ''primary'' because they deal with matters of major importance which should be addressed as soon as possible. Other recommendations of less immediate importance have been classified as ''secondary''. These relate to matters which generally would not be critical in terms of reducing the likelihood of blowouts.

The Panel has also identified a number of ''other'' recommendations that are beyond the terms of reference for Phase 2 of this inquiry, or may require action by agencies other than the ERCB.

4.2 Recommendation to Form a Review Committee

A recommendation that received wide support was that a joint ERCB/industry blowout prevention review committee be established. Participants stated that many of the matters dealt with required detailed technical and economic review, and that for others there was a lack of information available. They recommended that these be referred to the review committee for detailed assessment or study.

The Panel agrees that there is a need for a review committee. The committee should be made up of representatives of CAODC, IPAC, CPA, and the ERCB and representatives of the public and certain Government departments should be invited to participate on selected sub-committees of particular interest to them.

In subsequent sections of this report the Panel will identify those matters that the review committee should examine, indicating the urgency or time constraints.

5 PANEL VIEWS ON SPECIFIC RECOMMENDATIONS

5.1 Primary Recommendations

5.1.1 Critical Sour Well Definition

Participants in the inquiry generally agreed with the establishment of a category of ''critical sour wells'' that would recognize:

(a) the location of the well,
(b) the estimated maximum H_2S concentration, and
(c) the estimated maximum flow rate.

Special precautions and blowout prevention controls would then be practised at these wells.

The Panel agrees that there is considerable merit in defining and imposing special controls on critical sour wells. It also saw considerable urgency in this respect and consequently recommended that the ERCB take immediate action. A draft Interim Directive defining critical sour wells and setting special requirements for them is being issued simultaneously with this report and is attached as Appendix 5. It will be used on an interim basis for approximately six months. The review committee and representatives of public interest groups and Government departments will be asked to review and comment on it. A revised long-term policy will then be instituted.

5.1.2 Training

Almost all participants suggested increased attention to the training of rig crews, including more hands-on training during blowout prevention drills, with particular focus on training for the driller and those rig workers that report to him. Suggestions included certification of both the drilling foreman and rig manager, establishment of a third line blowout prevention certificate, specific training for the driller and the rig workers he supervises (derrickman, motorman, and roughnecks), an H_2S awareness course for crews, and an increase in management awareness of drilling practices and the consequences of failure.

The Panel believes that human factors are very significant in terms of preventing blowouts. For this reason, increased training could be a significant and effective factor in reducing blowouts and the Panel agrees with the participants that it should be pursued. In addition to the increased training in the conventional sense, eg, blowout drills, the Panel believes that an analysis should be made of how human errors cause blowouts, and what preventative action might be taken.

The Panel suggests that the matter of training should be a priority item and should be handled within six months of the formation of the review committee. A further analysis of human factors which cause blowouts should be pursued by the committee, or perhaps a sub-committee, over the longer term. Factors such as education and experience, age, health, safety attitudes, hours of work, turnover rates, fatigue, and boredom are examples which would be included in the terms of reference of the committee. An opportunity to comment on the recommendations of the committee should be given to Government departments such as Labour, Manpower, and the Workers' Compensation Board, to the public, and representatives of training services.

5.1.3 Increased Enforcement

The participants at the inquiry were divided with respect to increased enforcement of regulatory controls. One suggestion involved the suspension of the crew members' blowout prevention (BOP) certificates and shutting down well operations for infractions at well sites. Participants encouraged the ERCB and operators to ensure that blowout prevention drills were done properly and recorded.

The Panel agrees and has asked the ERCB to increase enforcement, particularly on critical sour wells and with respect to blowout prevention drills. Care should be taken in distinguishing between minor and serious infractions and the latter should result in suspension of rig operations until corrective action is taken. The Panel recommends that the review committee, with input from appropriate Government departments, consider the factors involved in the suspension of BOP certificates.

5.1.4 Inspection

The participants were supportive of increased ERCB and operator rig inspections, particularly with respect to critical sour wells at critical times during drilling.

The Panel agrees there is a need for increased inspection of wells drilling into abnormal pressure and high H_2S concentration formations and believes that inspection should take place prior to drilling critical portions of the well. The draft Interim Directive, Appendix 5, sets this out as a particular requirement for critical sour wells. The Panel is aware that the ERCB is analysing its rig inspection policy with respect to arrangements for rigorous and more frequent inspections of wells that may encounter sour gas.

5.1.5 Supervision

A strengthening in the number and experience of the on-site supervisory personnel by operator and contractor at wells drilling into sour formations was suggested by several participants. Specific suggestions included a special team for high pressure H_2S wells, a minimum 5-man crew on all sour wells, supervisors on 12-hour shifts for critical wells at critical times, and increased training for operator and contractor representatives.

The Panel agrees that supervision should be enhanced for drilling critical sour wells with particular attention to the critical drilling periods. The draft Interim Directive requires, for critical sour wells, a minimum 5-man crew, experienced supervisors on maximum 12-hour shifts, and additional specialized safety personnel on site at all critical drilling periods.

5.1.6 Special Drilling Equipment

Unanimous support was given for the formation of an ERCB/industry committee to review a multitude of equipment-related concerns with particular emphasis on equipment for sour gas drilling. The most important of these items were the improvement of drilling monitors and kick detection equipment, degassers, shear rams, inside BOPs, drill pipe, the need for H_2S-resistant equipment, and the location of the lower drilling spool.

The Panel is in agreement that the review committee should consider drilling equipment with emphasis on high pressure H_2S requirements. It believes the committee should bring forth recommendations as they are formulated and that the most important items should be dealt with in 6 to 12 months.

5.1.7 Information Exchange

The publication of the causes and circumstances of blowouts, drilling rig deficiencies found by ERCB inspections, and the gathering of drilling data from world-wide sources into a central location were suggested and generally supported by the participants.

The Panel agrees with the suggestions but notes that prior to the publication of drilling rig deficiencies, analysis and evaluation is required to ensure the data is meaningful. The Panel understands that the ERCB will, where possible, publish a report outlining the cause and circumstance of blowouts in Alberta. Appendix 3 is intended to assist in this regard. The Panel will recommend that the review committee establish a format for the gathering of drilling and other relevant data with particular emphasis related to drilling high pressure H_2S formations.

5.1.8 Site-Specific Emergency Response Plans

Some participants suggested that there should be site-specific emergency response plans for the drilling of critical sour hydrocarbon wells.

The Panel considers it essential for site-specific emergency response plans to be in place prior to the drilling of critical sour wells. This is reflected in the draft Interim Directive included as Appendix 5. The plan must include information as to how the public would be advised, protected, and evacuated if necessary, in the event of a blowout, and the plan must be discussed with the public. Emergency response plans were discussed extensively during Phase 1 of the inquiry and the Panel will be addressing the matter further in the Phase 1 report.

5.1.9 Drilling Plan

Participants generally agreed that drilling and geological data should be exchanged in order to improve drilling programs, but they recognized the constraints imposed by the confidential nature of geological data. Some participants were prepared to provide the ERCB with a copy of the drilling program, or a summary of it, and most indicated they already provide a copy to the drilling contractor.

The Panel urges operators to exchange geological information so that drilling programs can be designed in an optimum fashion for drilling into abnormal pressure and H_2S formations. As indicated in Appendix 5, a general description of the drilling plan and equipment to be used to drill a critical sour well must be submitted to, and approved by, the ERCB prior to the spudding of the well. The Panel will recommend that the review committee consider a method, suitable to industry and the ERCB, of exchanging geological information to assist in the development of drilling plans.

5.1.10 Mud System Design

The position taken by most participants was that mud system design should not be regulated, intentionally underbalanced mud programs should be eliminated, and appropriately safe mud programs should be followed for drilling into H_2S formations. Participants also commented on the importance of spare mud supply and differed in their opinions with respect to the use of stand-by tanks.

The Panel agrees that mud system design is a complex technical matter that must relate to the variable geological and drilling conditions at each well. It therefore does not lend itself to regulation. Nonetheless, very careful attention should be given to mud system design, particularly for high pressure H_2S formations with appropriate consideration being given to anticipated geological conditions in critical zones (pressure, permeability, formation fluids), the capacity of mud tanks, mud pH control, high speed mixers, and H_2S scavengers. The Panel recommends that this item be included for consideration by the review committee, including the possibility of a code of practice for mud system design.

5.1.11 Alberta Code of Practice for Drilling

The development of an Alberta code of practice for drilling with emphasis on sour gas wells was favoured by some participants. It was suggested that certain of the current regulations could be incorporated into a code of practice along with matters such as drill string design, drilling procedures, material and equipment specifications, and requirements for H_2S resistant blowout prevention equipment.

The Panel believes that the possibility of a code of practice for drilling should be considered by the review committee as a high priority.

5.2 Secondary Recommendations

5.2.1 Well Ignition

The participants suggested that a blowout well should not be automatically ignited because of the resulting damage to well control equipment, which in turn, would likely lengthen the duration of the blowout. It was suggested that the operator be given some time in which to formulate a control plan before ignition is considered.

The Panel agrees that a blowout well should not be automatically ignited in every instance but believes, because of the potential impact of certain wells at certain locations, that immediate ignition may be a necessity in some cases. The decision procedure as to whether the well should be intentionally fired in case of a blowout should be part of the emergency plan for sour wells. The Panel notes that because of the potential consequences which may occur, other Government departments and the public should be involved in determining ignition criteria. The Panel understands that the ERCB will initiate discussion in this regard with industry, Government, and the public. In the interim, if deemed appropriate by the ERCB, specific well licences will include a condition that the well be immediately ignited in case of a blowout.

5.2.2 Winter Drilling

Some participants expressed concern regarding a higher incidence of well problems, including blowouts, during winter months. Others suggested the statistics were being misinterpreted, and in any case any problem that existed could be eliminated by ensuring that the equipment was adequate for winter drilling.

The Panel believes that winter drilling can be conducted in a safe and effective manner providing the operator and contractor are sufficiently careful to ensure the adequacy of equipment and procedures to account for the severity of conditions.

The Panel recommends that the review committee consider the development of practical guidelines for equipment capabilities for winter drilling and the incorporation of them in any Alberta code of practice for drilling.

5.2.3 Contractors' Responsibility

One participant suggested that contractors should be given increased responsibility for the consequences of well control problems. The industry participants were united in their opposition to changing the existing contractual arrangements between the operator and the contractor.

The Panel believes that the responsibility for safe drilling practice must reside with the operator licensed to drill the well. It recognizes and supports the concept that certain requirements be contractually imposed on the drilling company, but does not believe that changes should be made to the existing situation where the operator has final responsibility.

5.2.4 Blowout Insurance

Insurance against blowouts was suggested to be far more expensive than small operators could afford. However, it was indicated that most major operators would have either blowout insurance or other corporate insurance that would cover a blowout incident.

The Panel is concerned that an uninsured operator with limited resources could have a major blowout which, in turn, could result in major economic impact to be covered by the public purse. The Panel understands that the ERCB intends to investigate further the need for and availability of blowout insurance and to consider whether it should be a requirement of each licensee.

5.2.5 Blowout Equipment Co-operative

A co-operative pool of blowout control equipment was suggested for use by any operator in the Province to assist in well control operations following a blowout. The CPA said it has maintained an equipment co-operative for several years at Golden Spike, Alberta, but the equipment has only been called out on three occasions and has never been used. This is apparently because the blowout control experts usually insist on using their own equipment.

Although the Panel can understand that blowout control experts in their very high risk work would want to use familiar equipment, it also believes that a pool of some blowout control equipment could be maintained and be of assistance to operators. The Panel recommends that the review committee give further consideration to this matter.

5.3 Other Recommendations

5.3.1 Safety

Safety concerns were raised by some participants in the inquiry who questioned the adequacy of the current regulations for breathable air supply on drilling rigs, the training in its use, and safety training for supervisors. Discussion also covered the length of a reasonable workday under stress conditions.

The Panel notes that the question of safety of workers at rig sites is within the jurisdiction of the Occupational Health and Safety Division of the Alberta Department of Workers' Health, Safety and Compensation, but believes that consideration of these matters should be initiated. The Panel will request that the ERCB contact the Occupational Health and Safety Division to initiate discussions on the matters set out in Appendix 8.

6 FINDINGS

Based on the evidence presented during Phase 2 of the inquiry, the Panel finds that

- The Alberta blowout experience appears comparable to that of other jurisdictions and costs vary greatly depending on the blowout severity.
- The Alberta blowout rate has steadily declined since the early 1970s, but sour gas blowouts continue to represent a disproportionate share of the total.
- It is probably not possible to completely prevent blowouts in Alberta but it is possible to reduce the frequency of blowouts by appropriate action.
- It is particularly important to develop and implement special measures that would be designed to prevent the blowout of "critical sour wells" and an ERCB draft Interim Directive is being issued for that purpose. It defines a critical sour well and requires approval by the ERCB, prior to spudding, of a general drilling plan, the equipment to be used, and an emergency response plan. Experienced supervisors and crews and increased inspections are also required.
- Industry and the ERCB need to work co-operatively to achieve the foregoing objectives and a review committee will be established with terms of reference and review items as summarized in Appendices 6 and 7 and referred to later in this section.

Some of the specific findings of the Panel are as follows:

- Addressing the role of human factors in preventing blowouts, improvements in crew training, rig inspection and reporting, drilling plans, mud system design, kick detection and response, and suspension of unsatisfactory rigs are likely to reduce blowouts and will be considered by the review committee.
- Improvements in equipment for H_2S drilling, with emphasis on blowout prevention equipment, drill pipe and degassers, will assist in reducing blowouts and will be considered by the review committee.
- Site-specific emergency response plans must be in place prior to drilling critical sour wells and the plans must reflect input from Government departments and the public.
- Exchange of information regarding rig inspections, blowout causes and circumstances, and drilling practices will assist in reducing blowouts and the most appropriate manner of doing this should be considered by the review committee.
- Criteria for ignition of blowout wells must be established with input from industry, Government, and the public. In the meantime, well licences for some wells in particular circumstances may include a condition for immediate ignition in the event of a blowout.
- Development of a code of practice for drilling, with emphasis on sour gas requirements, should be considered.
- The regulations regarding emergency breathing apparatus, air supply, and the safety of rig personnel need to be reviewed and the ERCB will initiate discussions with Alberta Workers' Health, Safety and Compensation.

ISSUED at Calgary, Alberta on 25 April 1984.

LODGEPOLE BLOWOUT INQUIRY PANEL

V. Millard Inquiry Panel Chairman	J. W. Markham, M.B. Panel Member
G. J. DeSorcy, P.Eng. Panel Member	N. A. Strom, P.Eng. Panel Member
F. A. Herbert, M.D. Panel Member	R. S. Weaver, Ph.D. Panel Member

APPENDIX 1 GLOSSARY OF TERMS

blooey line	— the discharge pipe of a well being drilled with air as the drilling fluid.
blowout	— an uncontrolled flow of gas, oil, or other well fluids into the atmosphere.
blowout preventer (BOP)	— the valve-like equipment attached to the casing at a drilling rig to prevent a blowout.
certificate (first and second line)	— certificates issued by the Petroleum Industry Training Service in blowout prevention and kick control procedures.
condensate	— that part of natural gas that is liquid at normal atmospheric conditions.
BOP stack	— the combination of valve-like devices, piping, and other fittings attached to the casing at a drilling rig.
casing (surface, production)	— the steel pipe placed in a well to prevent the collapse of the hole and provide a conduit for fluids during the drilling and producing phases.
circulating	— the pumping of drilling fluids down the drill pipe, out through the drilling bit, up the annulus, and back to the mud tanks.
coring	— a drilling operation which uses a special bit to produce a cylindrical sample or core of the rock penetrated.
degasser (mud-gas separator)	— a device which removes formation gas and air from drilling mud.
derrickman	— the member of the rig crew who normally handles the upper end of the drill pipe from a position up on the derrick. He is also responsible for maintaining the drilling mud.
directional survey	— a procedure to measure the direction and amount that a wellbore has deviated from the vertical.
diverter	— a device used in air drilling which conducts the return air and drill cuttings from the top of the well to the flare pit.
driller	— the member of the rig crew who operates the rig controls and is responsible for the rig and crew for one of the two or three shifts operating each day.
drilling	— the rotating of the drill pipe and bit and the circulating of drilling mud to cause penetration of formations.
drilling program	— a document prepared by the licensee of the well which contains instructions, diagrams, and other pertinent information and is the approved procedure for drilling the well.
drilling spool	— a spacer between components of the BOP stack, containing valved outlets.
drill pipe	— the heavy seamless pipe used to rotate the drilling bit and circulate the drilling fluid.
fishing	— to recover equipment such as broken drill pipe that has been lost in the wellbore.
formation	— a subsurface layer or deposit that is composed throughout of substantially the same kind of rock.
H_2S scavenger	— a material that deactivates any H_2S entering the wellbore.
hydrostatic pressure	— the pressure exerted by a column of fluid such as the drilling mud in the wellbore.
inside BOPs	— equipment designed to prevent blowout fluids from escaping up the inside of the drill pipe.
isopleth	— an imaginary line surrounding a point of potential contaminant release, formed by joining points of equal contaminant concentration (similar to a contour line).
kick	— the flow of gas, oil, water, or other formation fluids into the wellbore.

APPENDIX 1 (continued)

lost circulation — the loss of drilling fluid from the wellbore into a permeable formation.

motorman — the member of the rig crew who is responsible for the maintenance of the drilling engines, and who may also work on the rig floor.

mud (drilling) — the liquid circulated down the drill pipe and up the annulus during drilling.

permeability — a measure of the ability of fluids to flow through rock.

pH — the acidity or alkalinity of a fluid; a measure of hydrogen ion activity.

porosity — the open or void space within a rock.

rig manager (toolpush) — the employee of the drilling contractor who is normally at the well site and is in charge of the entire drilling crew and drilling rig.

roughneck — the members of the rig crew who usually work on the rig floor.

shear rams — a component of the BOP stack that can cut or shear through the drill pipe and form a seal against well pressure.

sour gas — natural gas containing H_2S in measurable concentration.

spud-in — to start drilling the wellbore.

swabbing — to pull the drill pipe up the wellbore too quickly and cause a sucking action within the wellbore.

testing — a procedure to test the type and quantity of fluids contained in a formation.

tour reports (pronounced ''tower'') — the daily record of activities at a drilling rig.

tripping (in/out) — the process of pulling all the drill pipe out of the hole to change a drill bit or other bottom-hole equipment, and then lowering the drill pipe back into the hole.

APPENDIX 2 THOSE WHO APPEARED AT PHASE 2 OF THE INQUIRY

Participants and Representatives (Abbreviations used in Report)	**Witnesses**
F. G. Bercha and Associates Limited (Bercha)	F. G. Bercha, P.Eng. B. J. Griffin, P.Eng. R. I. Macdonald
Confer Consulting Ltd. (Confer)	G. M. Engbloom, P.Eng.
K. L. Shaw	K. L. Shaw
Energy Resources Conservation Board staff (ERCB staff) M. J. Bruni	W. G. Remmer, P.Eng. E. F. May B. E. McFarlane
Pembina Area Sour Gas Exposures Committee (PASGEC) D. P. Mallon	K. R. Bissett C. Whitelock
C. Sams	C. Sams
Canadian Association of Oilwell Drilling Contractors (CAODC) J. B. Ballem, Q.C.	P. C. Grigg
Canadian Petroleum Association (CPA) F. R. Foran	I. M. Parker, P.Eng. H. Rath, P.Eng. H. Maciej
Independent Petroleum Association of Canada (IPAC) D. O. Sabey, Q.C. B. K. O'Ferrall	W. A. Elser, P.Eng. J. K. Farries, P.Eng.
Canterra Energy Ltd. C. P. MacDonald	W. H. Sawotin, P.Eng. D. Lewis, P.Eng. R. Reid, P.Eng. R. L. Thomas
Dome Petroleum Limited W. M. Smith	H. J. Strain, P.Eng. A. Wichert, P.Eng.
Gulf Canada Resources Inc. J. D. Anderson	L. D. Demosky, P.Eng. D. S. Belczewski F. C. Smith A. E. Wallace, P.Eng.
Petro-Canada Inc. J. W. Gallagher	R. T. McGrath, P.Eng. K. C. Brown W. E. Roeske, P.Eng.
Shell Canada Resources Limited J. D. Courtright	J. R. Tilbe, P.Eng. J. Piaskoski B. Straub, P.Eng.

APPENDIX 2 (continued)

Participants and Representatives (Abbreviations used in Report)	**Witnesses**
A. Scovil Murray	A. Scovil Murray, P.Eng.
Alberta Government Departments (Government departments) A. R. Watson	
Amoco Canada Petroleum Company Ltd. A. L. McLarty S. E. Lipton	
Inquiry staff R. D. Schachter J. K. Moloney E. J. Morin, P.Eng.	

APPENDIX 3 BLOWOUTS OF DRILLING WELLS* — 1983 TO 1974

Well Name	Date	Duration (days)	Depth (metres)	Loss	Cause
CONGASCOME ET AL SHEKILIE 12-14-118-8 (W6M)	27 Feb 1983	9	1794	610 x 10^3m^3 of gas (2% H_2S)	lost circulation
AMOCO DOME BRAZEAU RIVER 13-12-48-12 (W5M)	17 Oct 1982	67	3067	to be dealt with report	in detail in Phase 1
CANSTAR CALUMET OV 2-24-98-12 (W4M)	11 Feb 1982	13	65	85 x 10^6m^3 of sweet gas; rig burned	unexpected shallow gas sand; no BOPs installed
DOME SULPETRO VALHALLA 8-23-74-9 (W6M)	18 Jan 1982	4	2042	3618 x 10^3m^3 of gas (trace of H_2S)	failure to keep hole full while tripping out followed by BOP failure
HB SHEKILIE 9-16-118-8 (W6M)	18 Nov 1981	4	1548	1613 x 10^3m^3 of gas (0.66% H_2S); rig destroyed	lost circulation
PETROFINA TEST HOLE B5 13-6-51-7 (W5M)	15 May 1981	1	201	28 x 10^3m^3 of sweet gas; fire damage to rig	air drilling with no diverter or BOPs
RENAISSANCE PETMT EDWAND 7-10-61-17 (W5M)	1 Dec 1980	3	648	566 x 10^3m^3 of sweet gas; rig burned	lost circulation; surface casing split
BLAKE ET AL STEEN 10-9-112-1 (W6M)	7 Feb 1980	25	70	no estimate of sweet hydrocarbon loss; major rig fire damage	unexpected shallow gas sand
AMOCO ET AL STEEP 7-28-66-7 (W6M)	22 Nov 1979	3	2338	280 x 10^3m^3 of sweet gas	swabbing with fishing tools
SHELL RANDALL 12-10-81-2 (W5M)	26 Feb 1979	1	484	no estimate of hydrocarbon loss (sweet); fire damage to rig	failure of bleed-off hose on blooey line while air drilling
GULF POC GOLD RIVER 6-18-70-15 (W4M)	20 Dec 1977	2	505	60 x 10^3m^3 of sweet gas	loss of casing cement to weak zone
GAMMA ET AL CESSFORD 6-30-23-10 (W4M)	19 Dec 1977	33	952	1860 x 10^3m^3 of sweet gas; rig destroyed	swabbing while tripping out

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* Blowouts of wells being drilled whether sour or sweet, oil or gas, have been included.

APPENDIX 3 (continued)

Well Name	Date	Duration (days)	Depth (metres)	Loss	Cause
AMOCO PACIFIC BRAZEAU RIVER 7-10-48-12 (W5M)	6 Dec 1977	28	3311	16 x $10^6 m^3$ of gas (25% H_2S); rig destroyed	swabbing while tripping out; frozen equipment
WESTCOAST AEC SUFFIELD 8-13-20-8 (W4M)	4 Dec 1977	2	940	115 x $10^3 m^3$ of sweet gas	swabbing while pulling drill-stem test tools
DOME LPGS FT. SASK. 15B-14-55-22 (W4M)	13 Mar 1977	2 (hours)	964	30 x $10^3 m^3$ of sweet gas	loss of hydrostatic head while repairing mud pump
SHELL 35 WATERTON 12-9-3-30 (W4M)	28 Feb 1977	2	3148	56 x $10^6 m^3$ of gas (14% H_2S)	swabbing while tripping out
HUSKY NEERLANDIA 6-30-61-5 (W5M)	18 Jul 1975	1	174	no estimates (sweet gas)	swabbing while tripping out (plugged bit)
CDN-SUP CANSO BADGER 6-3-17-17 (W4M)	14 Mar 1975	4	1145	2433 x $10^3 m^3$ of sweet gas	insufficient mud weight
HBOG OIL SANDS Evaluation Hole 7-28-96-11 (W4M)	23 Jan 1975	2	118	21 x $10^3 m^3$ of sweet gas; rig destroyed	swabbing while tripping out
SUN CESSLAND JENNER 6-9-22-9 (W4M)	5 Sep 1974	2½	772	1817 x $10^3 m^3$ of sweet gas	abnormally high formation pressure
SUNDANCE ET AL DUNVEGAN 10-18-82-5 (W6M)	28 Feb 1974	10½	1510	1690 x $10^3 m^3$ of sweet gas	lost circulation; production casing failure

APPENDIX 4 ERCB RIG INSPECTIONS

25 April 1984

Canadian Association of Oil Well Drilling Contractors
Canadian Petroleum Association
Independent Petroleum Association of Canada
Pembina Area Sour Gas Exposures Committee, Mr. K. R. Bissett

ERCB INSPECTIONS OF DRILLING RIGS

During Phase 2 of the Lodgepole Inquiry, ERCB staff presented evidence of the results of its inspections of drilling rigs from 1979 to mid 1983. The evidence indicated that on average, the rigs on 33 per cent of all wells drilled during this period were inspected, 47 per cent were found to be unsatisfactory in some respect, and 83 per cent of the unsatisfactory cases had one or more serious deficiencies.

This evidence resulted in considerable concern and controversy regarding the data, and confusion with respect to how it should be interpreted. The ERCB staff indicated that the statistics had been compiled to assist it in the selection of rigs to inspect, and not for the purpose of assessing the overall quality of drilling operations in the Province. The staff recommended that it and industry representatives should meet to review the inspection forms used by the ERCB as well as the definitions adopted for classifying deficiencies as "serious".

Other participants agreed with this proposal. The Panel also agreed with it, and recommended that this letter be sent. The purpose of it is to invite your association to appoint one or two representatives to a Drilling Rig Inspection Committee under the chairmanship of Mr. Bill Remmer of the ERCB.

The proposed terms of reference of that committee are:

1. Review the inspection frequency policies to ensure that the number of inspections is adequate.
2. Review the ERCB Drilling Rig Inspection Form and the related instruction guides to determine whether they are appropriate for individual rig inspections and also for determining whether the overall state of rigs in the Province is adequate.
3. Review whether the current basis used by the ERCB for classifying inspection deficiencies as "serious" is appropriate.
4. Consider and recommend a procedure whereby the results of ERCB rig inspections might best be communicated to the operators, the contractors, and the public.
5. Consider whether and in what manner the inspections by the operator and contractor might be incorporated into the system.
6. Consider whether a rework of inspection results for 1983, using the appropriate definition of "serious", is possible and appropriate.

The Board considers this to be an urgent matter and seeks your assistance. It has requested Mr. Remmer to complete the review and submit recommendations by 30 June 1984. That report will be a public document.

I would appreciate your advice as to the names of your representatives by 10 May 1984. Attached is a package of information that will be relevant to the committee.

Yours truly,

V. Millard
Chairman

VM/kl
Enclosures

APPENDIX 5 DRAFT INTERIM DIRECTIVE ID 84-

To: All Operators, All Drilling Contractors,
and the General Public

BLOWOUT PREVENTION AT SOUR WELLS

Reference is made to the recently completed inquiry respecting the 1982 blowout at the AMOCO DOME BRAZEAU RIVER 13-12-48-12 well. The second phase of that inquiry was not related to the specific blowout but dealt with the broad subject of the prevention of blowouts in the Province as a whole.

There was considerable agreement among most participants on a number of the matters dealt with. One such matter related to the need for special safeguards against blowouts in the drilling of certain ''critical sour wells''. Discussion also took place respecting plans that would minimize impacts on the public should such a blowout occur.

The Board believes this matter to be of considerable importance and urgency and consequently is issuing this draft Interim Directive to define certain wells it considers to be ''critical'' and to establish requirements for the drilling of those wells. It recognizes that the special requirements will result in somewhat higher drilling costs for these wells but is convinced that these additional costs are warranted particularly having in mind that the potential cost of a blowout at one of these wells is very large. It should also be noted that the special requirements and related costs would apply only to a small portion of the total number of wells drilled in the Province. In 1983, fewer than 50 of the wells drilled would have been designated as ''critical sour wells''.

The Board intends that these interim requirements will apply for an approximate 6-month period, during which time the adequacy of them will be tested. Comments with respect to these requirements are invited prior to the end of October 1984, from industry, the public, and any other interested parties. The Board would expect to issue a new directive and, as necessary, amend the regulations at the end of the trial period, thus establishing a long-term policy respecting critical sour wells. At that time the Board will review and update, and combine where appropriate, its directives with respect to sour gas. (Interim Directive ID-OG-76-2, Emergency Procedure Plans For Sour Gas Facilities. Interim Directive ID 81-3, Minimum Distance Requirements Separating New Sour Gas Facilities From Residential and Other Developments.)

This draft Interim Directive is being included in the Phase 2 inquiry report. A task force or committee is being established to review certain of the matters discussed at Phase 2 of the inquiry. The Board believes that the committee should review the appropriateness of this draft directive and the policy it establishes, and should provide its comments by the end of October. If in the meantime and as a result of applying the requirements on an interim basis, particular problems or questions arise, the Board will refer such questions to the committee for its comments.

This interim policy does not change the minimum distance requirements separating sour gas facilities from residential and other developments as set out in Interim Directive ID 81-3. The policy respecting critical sour wells is as follows:

Definition

For blowout prevention purposes a critical sour well is defined as follows:

(a) any proposed well from which the maximum potential hydrogen sulphide (H_2S) release rate is greater than 2.0 cubic metres per second (m^3/sec),

(b) any proposed well from which the maximum potential H_2S release rate is greater than 0.3 m^3/sec and less than 2.0 m^3/sec if the well is to be located within 5 kilometres (3.1 miles) of an urban centre*, or

(c) any proposed well from which the maximum potential release rate is greater than 0.01 m^3/sec and less than 0.3 m^3/sec if the well is to be located within 1.5 kilometres (0.93 miles) of an urban centre, or

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* An urban centre is defined as a city, town, village, or other incorporated centre, and for the purpose of this directive includes any similar development the Board may designate as an urban centre.

(d) any other proposed well which the Board classifies as a critical sour well having regard to the maximum potential H_2S release rate, the population density, the environment, the sensitivity of the area in which the well is to be located, and the expected complexities in the drilling of the well.

Special Requirements

The applicant for a licence for a critical sour well must satisfy the following special requirements:

1 A satisfactory emergency response plan must be filed with the Board prior to the spudding of the well. The plan must meet the minimum content requirements set out in ID-OG-76-2 and must describe the manner in which the public would be notified, have their safety protected, and be evacuated if necessary, in the event of a blowout. The plan must also have been discussed with members of the rural public and urban representatives that reside within the maximum 100 parts per million isopleth which could be associated with the well. It should also deal with the manner in which the decision would be made as to whether the well would be intentionally ignited in case of a blowout.

This requirement for an emergency response plan is in addition to those set out in ID-OG-76-2 for gas plants and pipelines. Also, pursuant to section 7.060 of the Oil and Gas Conservation Regulations, the Board may continue to request emergency response plans for certain wells which are not ''critical sour wells'' under this directive.

2 A general description of the drilling plan and the equipment to be used to drill the well must be submitted to and approved by the Board prior to the spudding of the well. The plan would include geological data as necessary but be general in nature and briefly describe any serious drilling problems which may be expected and the manner in which they would be handled. It should also briefly address critical equipment such as the BOPs (including a discussion as to whether or not shear rams will be installed), the drill string, the degasser, the mud system, and procedures, to ensure that all such equipment is fully operative prior to penetrating the critical zone. The plan should also provide for the taking of a directional survey unless the operator can satisfy the Board that it is not needed.

3 The operator must satisfy the Board prior to spudding that supervision during the drilling of the well will be adequate. This will require on-site supervisors with Level 2 certification and some experience in drilling in sour areas. During critical periods at the well, such as drilling into the sour formation, sufficient supervision must be available so that no individual supervisor is required to work a shift longer than 12 hours.

4 The operator must satsify the Board prior to spudding that the drilling crew and key service personnel on the rig are adequate in number and sufficiently qualified. A minimum 5-man drilling crew will normally be required and at least some of the personnel should have experience in sour areas.

5 The operator must satisfy the Board prior to spudding that adequate safety personnel and safety equipment for workers will be on site at all critical times.

6 Intermediate casing set to an appropriate point above the zone from which sour gas or oil is expected will normally be required. However, the Board may exempt certain wells from this requirement if the applicant can demonstrate with a high degree of certainty that intermediate casing is not warranted.

7 A complete inspection and blowout prevention drill will be required prior to drilling out the surface casing and the intermediate casing and before penetrating the formation expected to contain sour gas. The Board field office must be notified at least 48 hours ahead of time so that staff may participate if judged appropriate.

8 If the well is not abandoned, completion and servicing operations will not be permitted without prior consent from the Board. Consent will be granted only if the Board is satisfied that proper equipment and trained personnel will be used and that adequate precautions to prevent a blowout will be taken.

APPENDIX 5 (continued)

Additional Information to Support Well Licence Applications

The maximum potential H_2S release rate must be submitted as part of a licence application for any well and should be calculated on the basis of the maximum flow rate and H_2S content which can be expected. It should reflect all information available from wells in the area and a realistic engineering approach which recognizes the expected geological setting and reservoir fluid. A detailed description of the type of information required is set out in Attachment I.

Information respecting the maximum potential release rate along with plans for satisfying the above special requirements should be submitted with a licence application for any well which would be a ‘‘critical sour well’’ in accordance with the definition in this directive. In instances where the Board decides that a critical designation should be attached to a well which does not otherwise qualify in accordance with this directive, the applicant for a licence will be sent a deficiency letter requesting information to satisfy the special requirements.

The additional information provided the Board to determine the maximum potential H_2S release rate or to satisfy the above listed special requirements will, with certain exceptions, be considered as public information. Where geological data or personal information respecting individuals is provided as part of the submission, the Board will, upon request from the applicant, consider it as confidential. Such information should be included in a separate volume to avoid inadvertant release. In situations where a well licence application goes to a public hearing the matter can be decided on the basis of only that information which is public. However, the applicant will be provided with an opportunity to reclassify as public, all or a modified part of the data originally filed as confidential.

Comments regarding this directive from industry, the public, or other interested parties should be addressed to the Manager, Development Department (297-8169).

Applicants requiring further information regarding well licensing should address their inquiries to the Well Licensing Section (297-8159) and regarding emergency response plans to the Environment Protection Department (297-8324).

ISSUED at Calgary, Alberta on 25 April 1984.

Vernon Millard
Chairman

Attachment

ATTACHMENT I (ID 84-)

Where an application is made to the Board for a well licence, the applicant shall include in the application the information required in either A or B, as applicable.

A A statement and supporting evidence to the effect that none of the formations to be encountered during the drilling of the well are expected to contain hydrogen sulphide (H_2S).

or

B 1. For each formation to be penetrated which may contain H_2S:

(a) the maximum expected concentration of H_2S, and the source of this information,

(b) the maximum expected flow capability at the surface for the case where the unstimulated formation is open to the wellbore as during drilling, and for the case where the well has been completed and the formation stimulated, and the method and information used to determine these values,

(c) the calculated potential H_2S release rate expressed in the units of cubic metres per second for each of the two cases referred to in (b) above.

2. The maximum potential uncontrolled release rate of H_2S at the stage in the drilling of the well where the sum of the release rates from each formation open to the wellbore is a maximum.

3. The maximum potential uncontrolled release rate of H_2S during the producing stage for the well.

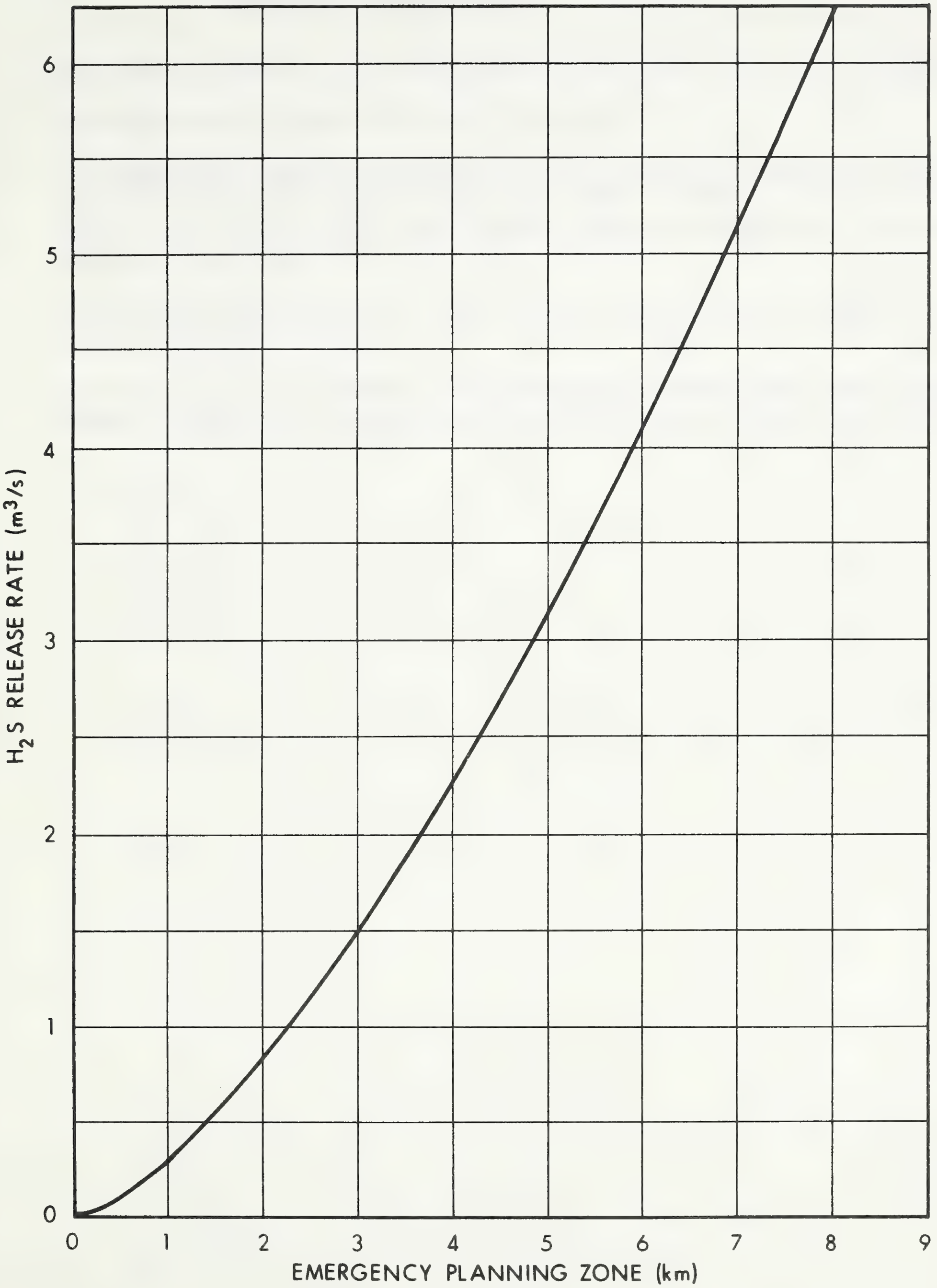
4. The radius of the emergency planning zone for each of 2 and 3 above, determined from the graph in Figure 1 to this Attachment.

5. A map showing the location of all residences and public facilities located within the larger of the emergency planning zones.

6. A statement of the distance to the nearest permanent residence, public facility, rural subdivision, or urban centre beyond the larger of the emergency planning zones, plus an indication of the population density in the general area beyond the planning zone a distance approximately equal to the radius of the planning zone.

It is emphasized that a realistic, responsible engineering approach must be taken. The expected geological setting and reservoir fluids to be encountered must be recognized along with all relevant tests and analyses for the area. In order that the best possible information be available all operators are urged to file the results of tests and analyses with the Board as soon as possible following the completion of the tests.

FIGURE 1 TO ATTACHMENT I
EMERGENCY PLANNING ZONES FOR SOUR GAS WELLS



APPENDIX 6 BLOWOUT PREVENTION REVIEW COMMITTEE TERMS OF REFERENCE

1. Membership will consist of two representatives from each of the ERCB, CAODC, CPA, and IPAC.

2. The Chairman and the Secretary will be the ERCB representatives.

3. The Committee will, through sub-committees if appropriate, investigate, develop recommendations, and report to the parent organizations on each of the subjects listed in Appendix 7.

   Subjects identified as high priority will be reported on or before 1 November 1984. All others will be reported on or before 1 July 1985.

4. The first meeting of the Committee will be held no later than 1 June 1984, and the Committee will remain active as long as the need continues.

5. Government agencies and representatives of the public will be consulted on those matters identified in Appendix 7 and they will be considered for membership on the relevant committees or sub- committees.

APPENDIX 7 BLOWOUT PREVENTION REVIEW COMMITTEE TABLE OF ACTIVITIES AND PRIORITIES

NO.	ACTIVITY	PRIORITY	REFERRED TO IN REPORT (section no.)
1	Critical Sour Well Definition	High	5.1.1
2	Training — Human factors — Driller and crew — Hands-on crew training — 3rd-line supervisors — Surprise drills — Review certification levels — Review certification periods — H_2S awareness — Management awareness — Follow-up — Effectiveness	High	5.1.2
3	Enforcement — Suspension of BOP tickets	Moderate	5.1.3
4	Inspection — More rigorous & frequent function testing of BOPs — Drilling out casings — Entering critical formations — Identify critical depths — Rig deficiency statistics[1]	High	5.1.4
5	Supervision — Special teams for H_2S wells — Two supervisors on critical wells — 2nd-line certificate — 12-hour shifts — BOP drills	High	5.1.5

---

[1] The ERCB staff has already started work with the Phase 2 participants to resolve the difficulties with these statistics.

APPENDIX 7 (continued)

NO.	ACTIVITY	PRIORITY	REFERRED TO IN REPORT (section no.)
6	Special Drilling Equipment — Improve kick detection equipment — Monitoring — Degassers — Shear rams[2] — Inside BOPs (floats) — Drill pipe design and metallurgy — H_2S resistant equipment — Location of lower drilling spool — Location of HC valve — Manifold redundancy — Casing pressure gauges — BOP configuration — Master controls location — More automation — Equipment specifications — Drill-string inspection	High	5.1.6
7	Information Exchange — Gather drilling data	Moderate	5.1.7
8	Drilling Plan — Well planning execution — Kick detection/response — Drilling procedures entering critical zone — Tripping and coring procedures — Entering the formation — Lease preparation — Directional surveys — Drill-stem testing — Exchange geological information	Moderate	5.1.9

---

[2] PASGEC specifically requested input to these items and the committee must ensure that it is kept informed.

APPENDIX 7 (continued)

NO.	ACTIVITY	PRIORITY	REFERRED TO IN REPORT (section no.)
9	Mud System Design — Underbalanced programs — Conservative mud weights — Mud capacity — pH — H_2S scavengers — Geological conditions — Mud and gas monitoring[2] — Drilling fluids	Moderate	5.1.10
10	Code of Practice for Drilling — Drilling procedures — Tripping and coring — Formation testing — Drill-string design — BOP equipment — Equipment specifications — H_2S-resistant materials	High	5.1.11
11	Winter Drilling Guidelines	Moderate	5.2.2
12	Blowout Equipment Co-operative	Moderate	5.2.5

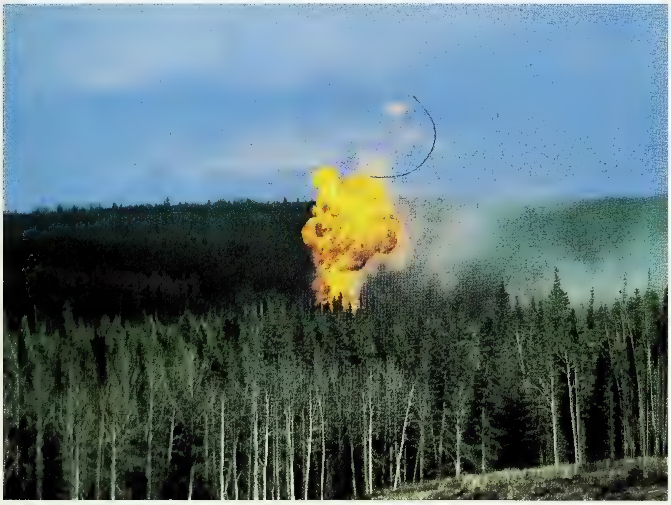
APPENDIX 8 MATTERS TO REFER TO OCCUPATIONAL HEALTH AND SAFETY TABLE OF ACTIVITIES AND PRIORITIES

NO.	ACTIVITY	PRIORITY	REFERRED TO IN REPORT (section no.)
1	Health and Safety — Emergency breathing equipment — Air supply — Training for Supervisors — 12 hour shifts — Safety personnel at critical times — Air monitoring — Respiratory equipment and training	High	5.3.1

APPENDIX 6 PHOTOGRAPHS OF THE 13-12 BLOWOUT

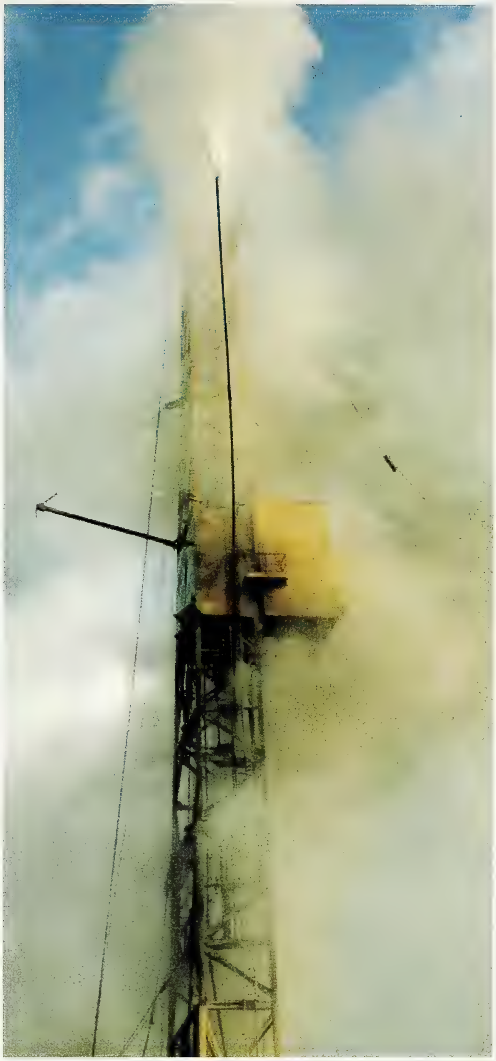
Photographs of the blowout of the 13-12 well showing various scenes, mostly at the site, as the events unfolded.

The 13-12 blowout area prior to the first fire.
Photo credit: W. Wylie, ERCB



First ignition of the 13-12 well. Note the drill pipe above the flame.
Photo credit: W. Wylie, ERCB

Fire following accidental ignition of 13-12 well.
Photo credit: C Wickstrom, ERCB.



Plan "B" fails. Note the drill pipe
blowing out of the well.
Photo courtesy Standard Safety & Consulting Services (1978) Ltd.

Some of the drill pipe blown out of the well.
Photo credit: W. Wylie, ERCB

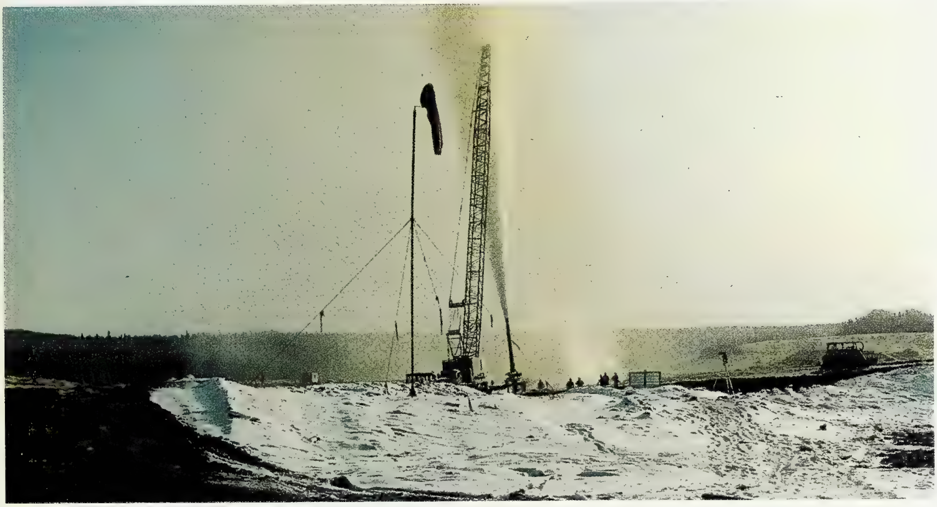
On-site rescue ambulance and workers.
Photo credit: W. Wylie, ERCB

The burned-out area after the first fire.
Photo credit: W. Wylie, ERCB

The blowout preventer stack recovered after the first fire.
Photo credit: W. Wylie, ERCB

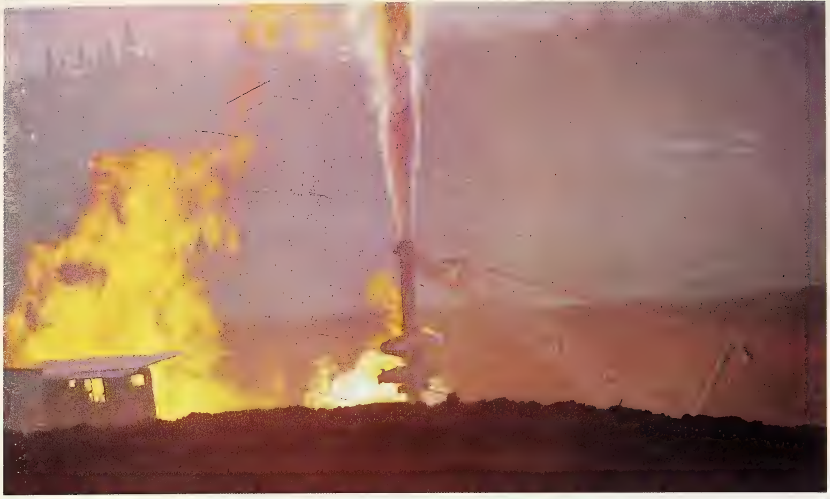
One of the attempts to extinguish the fire.
Photo credit: W. Wylie, ERCB

Mobile air monitoring vehicle.
Photo courtesy Alberta Environment

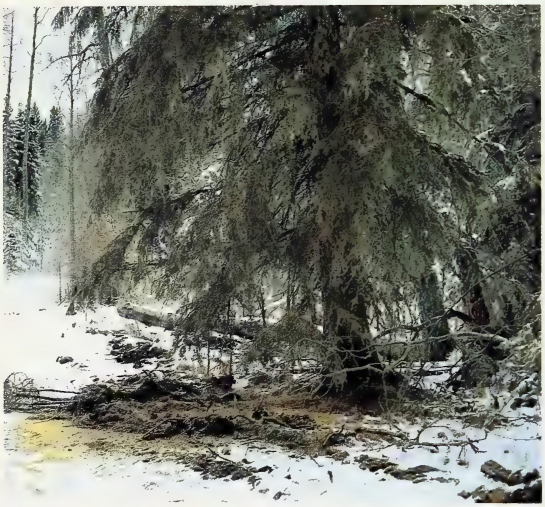


With the fire out, workers attempt to cap the well (Plan "C").
Photo courtesy Standard Safety & Consulting Services (1978) Ltd.

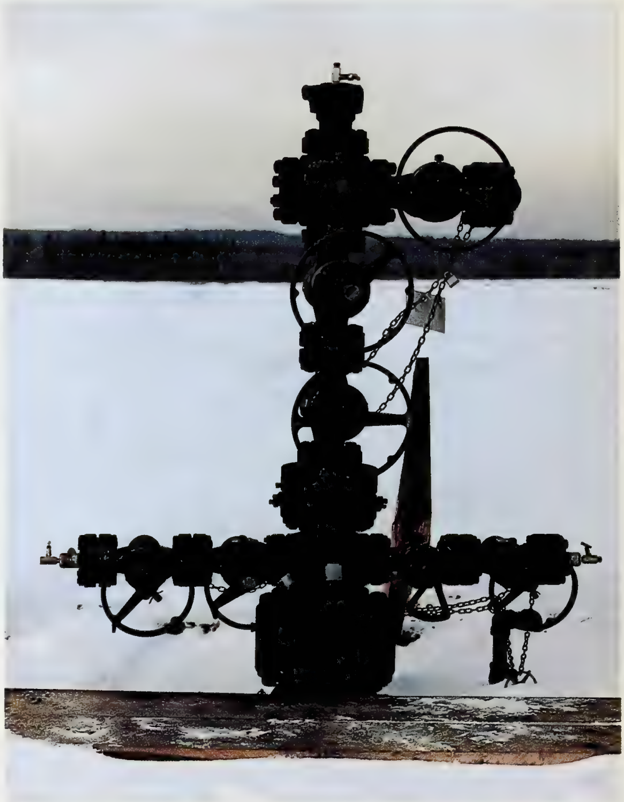
Well-site worker suited and masked-up.
Photo courtesy Standard Safety & Consulting Services (1978) Ltd.



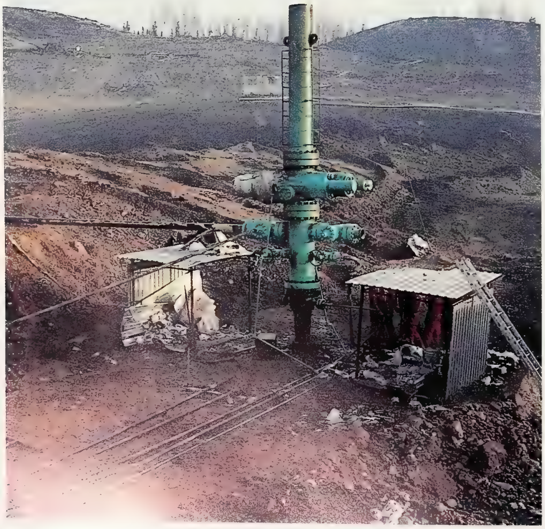
Final capping of the 13-12 well begins.
Photo credit: W. Wylie, ERCB



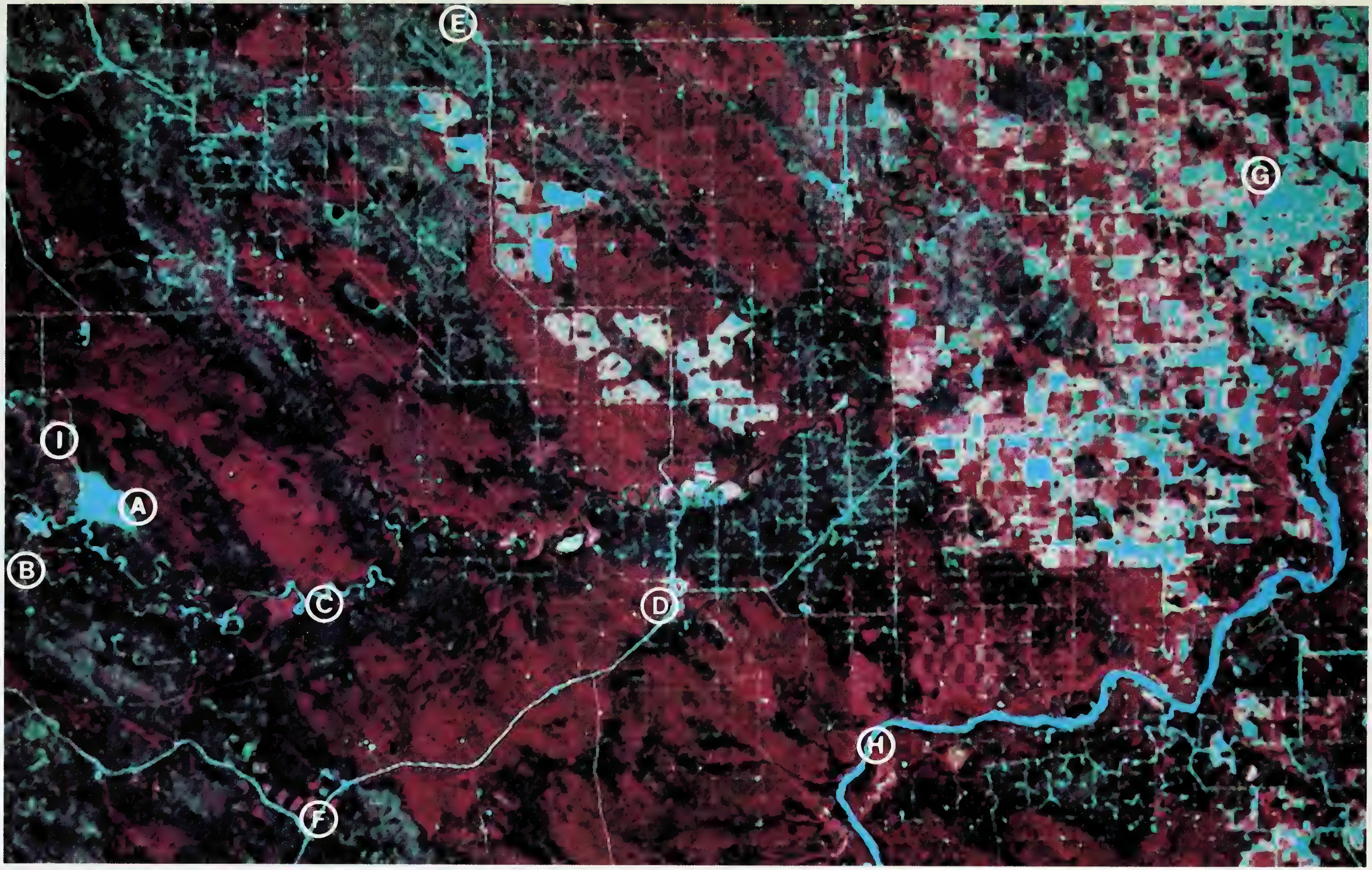
Condensate laden tree near Zeta Creek.
Photo credit: W. Wylie, ERCB



The 13-12 wellhead after completion of the well.
Photo credit: D. Peet, ERCB



The battle with 13-12 is over!
Photo credit: R. Paulson, ERCB



This satellite photo, of a 30 by 20 mile area surrounding the Lodgepole Blowout, was taken in August of 1983.

PLACES OF INTEREST

A	Blowout site, 13-12 well (1982)
B	Blowout site, 7-10 well (1977)
C	Pembina River
D	Lodgepole
E	Cynthia
F	Centennial Lumber
G	Drayton Valley
H	North Saskatchewan River
I	Zeta Creek

COLOURS IN PHOTO

*Brilliant blues (heavily sedimented rivers).

*Pale blue (bare or fallow fields, including two blowout sites).

*Deep red (poplar forest).

*Magenta to brown (muskeg, with trees).

*Black (clear lakes with muck bottoms).

APPENDIX 7 METHOD OF PRESENTING H_2S AIR MONITORING DATA AS USED BY ALBERTA ENVIRONMENT AND AMOCO WHEN OFF-SCALE READINGS WERE ENCOUNTERED BY MOBILE MONITORING INSTRUMENTS

The instruments used in H_2S mobile air monitoring for the blowout incident, some of which had continuous recording capability, had limits which were exceeded by concentrations of H_2S encountered by the instruments. AE, and Amoco's consultant, Monitrex Engineering Ltd., reported the readings for these occurrences in the following manner:

AE

The AE mobile unit monitoring in high H_2S concentration areas had a maximum capability of 30 ppm and did not have a continuous recording device. AE reported a low concentration and high concentration for each monitoring period reported using this machine. The recordings are from a visual observation of a needle scale on the instrument.

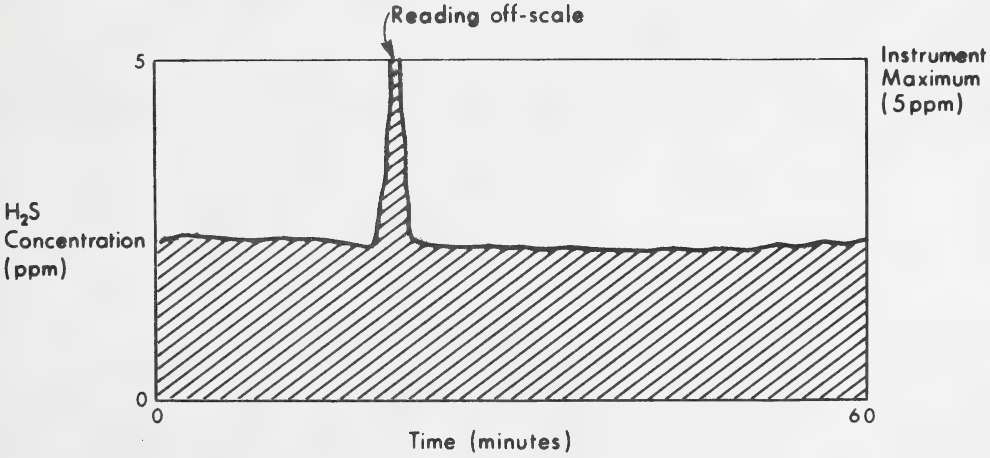
If the instrument went off scale, AE reported this occurrence with the greater-than sign (>) preceding the instrument's maximum (ie, > 30 ppm).

Monitrex

The two mobile monitors used by Monitrex had a recording capability of 5 and 10 ppm, respectively, and each had continuous recording strip chart equipment.

Monitrex presented its mobile and stationary monitoring data in hourly averages using two methods for periods when off-scale readings were obtained:

(a) if the peak off-scale reading lasted for 1 minute or less, the reading would be shown as the average value of the area under the curve. For example:

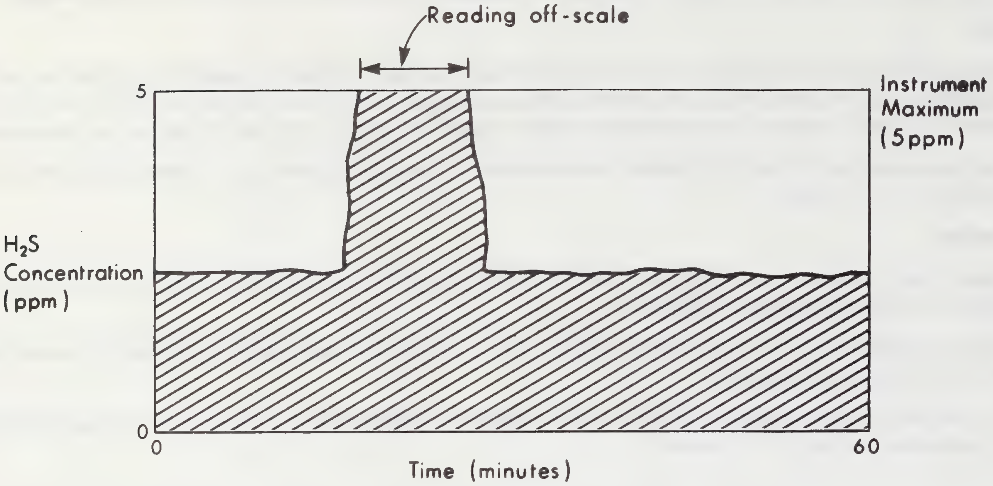


if the area under the curve above (shaded) averages 2.5 ppm, the reading would be presented as an hourly average of 2.5 ppm,

and,

APPENDIX 7 (continued)

(b) if the peak off-scale reading lasted for longer than 1 minute, the reading would be shown as an hourly average of greater than the maximum capability of the machine. For example:



if the off-scale portion as shown above lasted longer than 1 minute, the reading would be shown as greater than 5 ppm, ie, > 5 ppm.

APPENDIX 8 GOVERNMENT OF ALBERTA — PEACETIME EMERGENCY OPERATIONS PLAN FOR A SOUR GAS RELEASE

Government of Alberta

Peacetime Emergency Operations Plan
For a Sour Gas Release

13 April 1984

GOVERNMENT OF ALBERTA

PEACETIME EMERGENCY OPERATIONS PLAN

FOR A SOUR GAS RELEASE

April 13 1984

(Date)

I.D. MARK EGENER
MANAGING DIRECTOR
ALBERTA DISASTER SERVICES

M E Moore

MARVIN E. MOORE
MINISTER-IN-CHARGE
ALBERTA DISASTER SERVICES

GOVERNMENT OF ALBERTA

PEACETIME EMERGENCY OPERATIONS PLAN

FOR A SOUR GAS RELEASE

PURPOSE

1. This plan sets forth the manner in which the Alberta Government departments and agencies will respond to a sour gas release which may affect people and property in Alberta.

AUTHORITY

2. This plan is issued by the Minister responsible for Alberta Disaster Services under the authority of the Disaster Services Act and authorizes the government to respond in a prompt and co-ordinated manner to any release of sour gas.

DEFINITIONS

3. In this plan:

   a. a **sour gas release** is an uncontrolled release of natural gas containing hydrogen sulphide which is so declared to be a Sour Gas Release by the Energy Resources Conservation Board (ERCB).

   b. the **FH Order area** is that area within the boundaries delineated in an FH Order issued by ERCB under Section 89 of the Oil and Gas Conservation Act.

   c. **Minister** means the Minister charged with the administration of The Disaster Services Act.

   d. an **On-site Command Post** is an operations centre set up in the vicinity of the gas release to manage the emergency within the FH Order Area.

   e. a **Main Control Headquarters** is an operations centre set up at a suitable location in support of the On-Site Command Post to manage the larger aspects of the emergency including public relations and the provision of information and advice to affected municipalities.

   f. **Police** is a peace officer as defined in Section 25(1) (0.1) of the Interpretation Act, Chapter I-7 R.S.A. 1980, as being a member of the Royal Canadian Mounted Police or a member of a municipal police force having jurisdiction in Alberta by virtue of Section 18 (1) and Section 19 of the Police Act, Chapter P-12 R.S.A. 1980.

   g. **Local Authority** means:

      (1) the council of a city, town, village, county or municipal district

(2) the board of administrators of a new town; and

(3) in the case of an improvement district or special area, the Minister of Municipal Affairs.

h. **Municipal Emergency Plans** means those emergency plans prepared by a Local Authority pursuant to Section 8(e) of the Disaster Services Act or by or in respect of a Metis Settlement.

i. **Company Emergency Plans** means emergency procedures plans prepared by an industrial operator pursuant to regulation 7.060 (9) (gas wells) or 9.060 (gas plants) made under the Oil and Gas Conservation Act, Regulation 65 made under the Pipeline Act (pipelines) or any other regulation, statute or condition.

GENERAL

4. Sour gas may contain contaminents in concentrations that could be potentially dangerous to the health and safety of people should they become exposed during a release. This plan outlines a method of responding to such an emergency when a sour gas release is declared by ERCB and should be viewed as a plan of general application. This plan describes the concept of operations, responsibilities of Alberta government departments and agencies, and some detailed aspects of the management of the emergency. In the event of any conflict between this plan and existing Acts or Regulations, those Acts or Regulations will take precedence.

IMPLEMENTATION

5. This plan will be implemented in part or in whole on the direction of ERCB.

6. Concept. The response should proceed as follows:

a. ERCB will be made aware of the threat of or the occurrance of an actual sour gas release, by the industrial operator (the licencee) or by other means;

b. ERCB will direct that this plan be activated, in part or in whole, will commence the alerting procedures and will prepare and issue, if appropriate, an FH Order;

c. in accordance with Company Emergency Plans or on the direction of ERCB, the well may be fired;

d. ERCB will establish two headquarters (see Annex A) to manage the response if required:

(1) an On-Site Command Post to deal with matters within the immediate area of the gas release. When a FH Order is made, the immediate area of the release will be the FH Order area; and

.../3

  (2) a Main Control Headquarters to deal with matters outside the immediate area of the release to provide support to the On-Site Command Post and to provide an interface with the public, the local authorities and the Government of Alberta.

e. ERCB will direct the activities at the On-Site Command Post and the industrial operator's activities related to the sour gas release. Workers' Health, Safety and Compensation has the responsibility for ensuring that all safety measures are observed at the work site;

f. ERCB will direct the activities at the Main Control Headquarters and will co-ordinate the activities of the departments and other government agencies represented there;

g. the Main Control Headquarters' channels for communication (see chart at Annex B) will be:

  (1) to the On-Site Command Post;

  (2) to those Local Authorities represented at the Main Control Headquarters;

  (3) through Alberta Disaster Services to other Local Authorities;

  (4) to those government departments represented at the Main Control Headquarters;

  (5) through Alberta Disaster Services to government departments not represented at the Main Control Headquarters; and

  (6) through Alberta Disaster Services to the Government of Canada except where direct communications are authorized.

h. the Main Control Headquarters is the main source of official information to the public, including health risk and other warnings; and

i. if the situation escalates requiring such additional government support that, in the opinion of the ERCB, it would be difficult to continue to manage all matters at the Main Control Headquarters, Alberta Disaster Services would be tasked to activate the Government of Alberta Emergency Response Centre, to co-ordinate those activities which are impractical to manage at the Main Control Headquarters. The Emergency Response Centre would then be activated in accordance with the Government of Alberta Peacetime Emergency Operations Plan and Procedures.

7. Alerting. ERCB may learn of a sour gas release from many sources. Any government department or agency receiving information regarding a sour gas release will notify ERCB immediately.

.../4

ERCB will immediately alert:

a. Alberta Disaster Services who will in turn alert:

    (1) all other departments, boards, agencies and crown corporations who will be involved in the Main Control Headquarters;

    (2) all municipalities which are or which may be affected;

    (3) any other orders of government which might be involved; and

    (4) any other organizations which might have a role to play or which could otherwise be affected.

b. the RCM Police and/or such other police forces have jurisdiction in the areas involved;

c. the public threatened or potentially threatened;

d. all local authorities whose geographic area is or might be affected by the release;

e. Alberta Environment;

f. Workers' Health, Safety and Compensation;

g. Energy and Natural Resources.

8. Responsibilities

a. The Government of Alberta, its departments and agencies including the ERCB is responsible for:

    (1) developing and maintaining a plan and procedures for a co-ordinated response to a sour gas release;

    (2) establishing an On-Site Command Post and a Main Control Headquarters to co-ordinate the Government's response;

    (3) directing and controlling operations at the location of the sour gas release including, where an FH Order has been made, control of access and egress within the FH Order area;

    (4) providing prompt, co-ordinated assistance and advice to municipalities and the industrial operator engaged in a response to the sour gas release;

    (5) providing information and advice to the public concerning the sour gas release and advice to the people who are or could be affected;

.../5

(6) co-ordinating dealings with and co-operating with the Government of Canada as required;

(7) in the case of an escalation of the emergency, providing additional co-ordinated assistance to the On-Site Command Post and Main Control Headquarters by activating the Government of Alberta Emergency Response Centre.

Detailed On-Site Command Post and Main Control Headquarters functions are at Annex C and departmental and ERCB responsibilities are at Annex D to this plan.

b. Incorporated Municipalities are responsible for implementing their Municipal Emergency Plans to protect the health, safety and welfare of residents, using any or all of the resources available to the municipality;

c. Improvement Districts, Special Areas and Metis Settlements- the Minister of Municipal Affairs is responsible for implementing Municipal Emergency Plans to protect the health, safety and welfare of Improvement District, Special Area and Metis Settlement residents; and

d. Industrial operators will be responsible for implementing their Company Emergency Plans until otherwise directed by ERCB.

NOTE: To avoid jurisdictional confusion, note that the Local Authorities would continue to exercise their normal responsibilities outside of the FH Order area.

9. Monitoring. ERCB will ensure that sufficient monitoring information is gathered so that the ERCB is able to meet their responsibilities under this plan. Obtaining information on contamination levels of hydrogen sulphide and other contaminants is the responsibility of:

a. Workers' Health, Safety and Compensation wherever there are workers that may be affected; and

b. Alberta Environment for all other areas.

10. Public Advisory. Whenever monitoring information indicates that a threat or potential threat exists to members of the public the ERCB or the Main Control Headquarters once it is established, will notify:

a. the public threatened or potentially threatened; and

b. all Local Authorities whose geographical area is or might be affected by the release.

Notwithstanding the aforesaid, if the industrial operator or Alberta Environment, through their monitoring or otherwise, become aware of concentrations of contaminants that present an immediate threat to persons in the area, the industrial operator or Alberta Environment as the case may be, will immediately notify those persons and the On-Site Command Post or the Main Control Headquarters of such a threat.

.../6

11. Evacuation. Evacuation may take many forms and could range from a few individuals to entire small communities exposed to sudden or accumulated concentrations of sour gas. Such action will be recommended to the municipality by the Main Control Headquarters. Evacuation advice will be in one of four general categories. These are:

a. Voluntary. Where the authorities do not consider the hazard sufficient to warrant advising evacuation, some individuals may choose to leave of their own accord.

b. Advisory. Where there may be a hazard to people with respiratory or other health problems, they would be advised to leave;

c. Urgent. Where there is a serious hazard and people's health and welfare could be adversely affected if they didn't leave immediately, this information would be passed by the most expeditious means available which could be by telephone, by loud hailer or by going door-to door; and

d. Enforced. ERCB has the authority to order evacuation out of an FH Order area. A municipality may acquire authority to order evacuation of any part or all of its area of jurisdiction by declaring a State of Local Emergency under The Disaster Services Act.

12. Reception. Alberta Disaster Services will alert those municipalities designated for reception of evacuees and will co-ordinate reception arrangements, where necessary.

13. Security.

a. The RCM Police will be responsible for the control and the security of any evacuated areas in the absence of a recognized municipal police force; and

b. the ERCB will arrange for control of air traffic through the area through the Federal Ministry of Transport who will in turn issue a NOTAM (Notice to Airmen) or a special Federal Ministerial Order.

14. Situation Reports. All Government of Alberta departments, boards and agencies involved in the emergency response will provide the Main Control Headquarters and On-Site Command Post with a situation summary daily, or as otherwise required, which will be amalgamated into a Government situation report.

15. Public Information. The Public Affairs representative at the Main Control Headquarters will manage and release information to the media on behalf of the Main Control Headquarters. The Public Affairs Bureau will establish and staff a public inquiry centre for the Main Control Headquarters for briefing media and responding to inquiries from the general public.

.../7

DISTRIBUTION

ACTION

Minister-in-charge, Alberta Disaster Services

- Executive Assistant

Alberta Disaster Services

- Managing Director
- Assistant Executive Director (DP)
- Assistant Executive Director (DG)
- Division Directors
- District Officers
- Staff Officers
- Emergency Response Centre
- Spares

Government Departments

- Emergency Planning Officers and Alternate Emergency Planning Officers

INFORMATION

Alberta Municipalities

- Directors of Disaster Services, Incorporated Muncipalities

Alberta Legislative Library

- Provincial Archives of Alberta

Government of Canada

- Regional Director, Alberta, Yukon and Northwest Territories, Emergency Planning Canada

- Federal Study Centre, Arnprior, Ontario

- Regional Director, Indian and Northern Affairs

- Director, Western Region, Parks Canada

- Superintendents, National Parks in Alberta

- K Division RCMP

- Commander, Air Command Detachment Edmonton

Provincial/Territorial Emergency Preparedness Organizations

- Canadian Petroleum Association

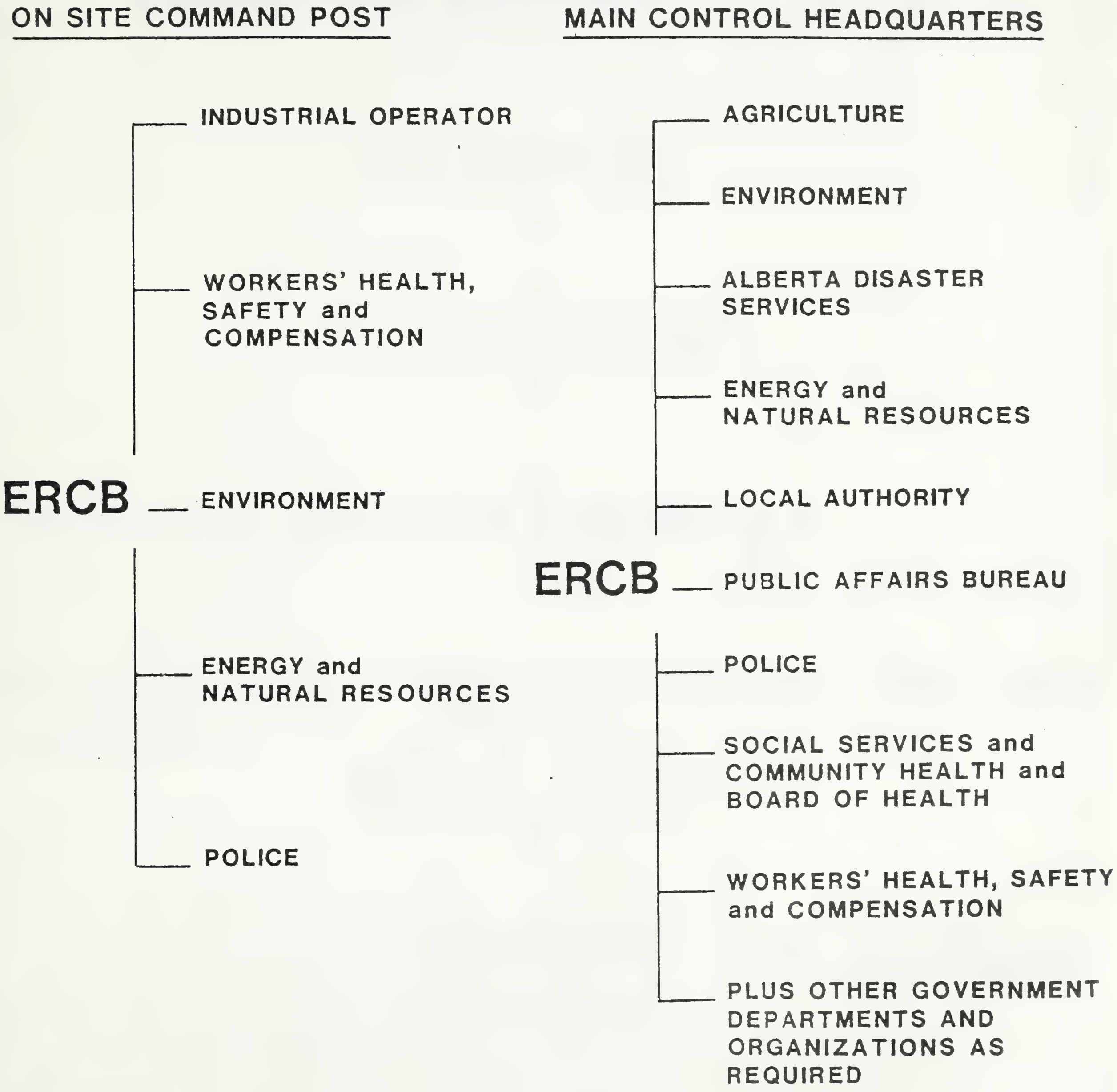
- Independent Petroleum Association

- Edmonton Pipeline and Utility Operators

- Alberta One - Call

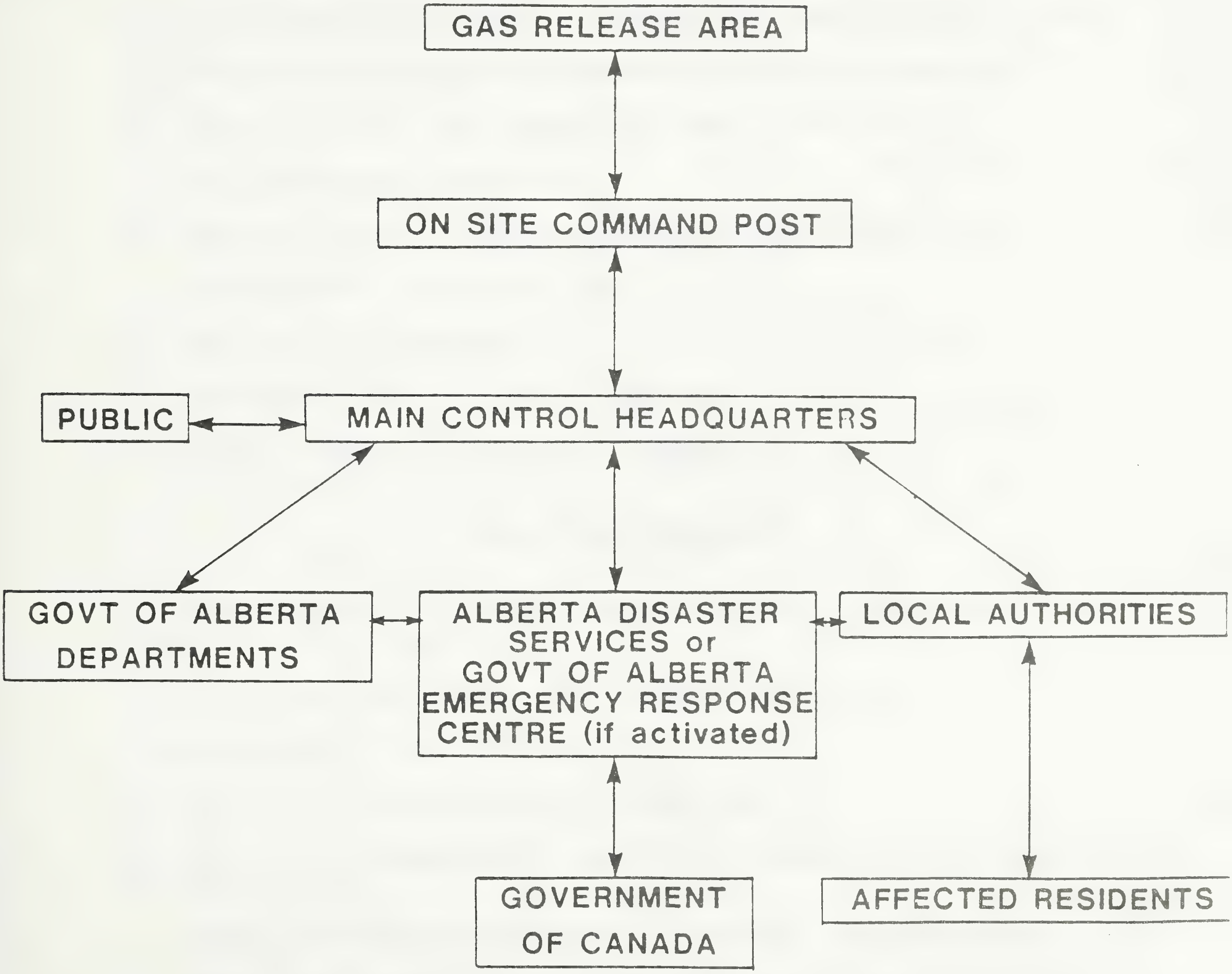
Annex A to
Government of Alberta
Peacetime Emergency
Operations Plan for a
Sour Gas Release

SOUR GAS RELEASE
EMERGENCY RESPONSE ORGANIZATION


ON SITE COMMAND POST
ERCB
INDUSTRIAL OPERATOR
WORKERS' HEALTH, SAFETY and COMPENSATION
ENVIRONMENT
ENERGY and NATURAL RESOURCES
POLICE
MAIN CONTROL HEADQUARTERS
ERCB
AGRICULTURE
ENVIRONMENT
ALBERTA DISASTER SERVICES
ENERGY and NATURAL RESOURCES
LOCAL AUTHORITY
PUBLIC AFFAIRS BUREAU
POLICE
SOCIAL SERVICES and COMMUNITY HEALTH and BOARD OF HEALTH
WORKERS' HEALTH, SAFETY and COMPENSATION
PLUS OTHER GOVERNMENT DEPARTMENTS AND ORGANIZATIONS AS REQUIRED

Annex B to
Government of Alberta
Peacetime Emergency
Operations Plan for a
Sour Gas Release

SOUR GAS RELEASE
EMERGENCY INFORMATION FLOW


GAS RELEASE AREA
ON SITE COMMAND POST
PUBLIC
MAIN CONTROL HEADQUARTERS
GOVT OF ALBERTA DEPARTMENTS
ALBERTA DISASTER SERVICES or GOVT OF ALBERTA EMERGENCY RESPONSE CENTRE (if activated)
LOCAL AUTHORITIES
GOVERNMENT OF CANADA
AFFECTED RESIDENTS

Annex C to
Government of Alberta
Peacetime Emergency
Operations Plan for a
Sour Gas Release

SOUR GAS RELEASE

FUNCTIONS

ON SITE COMMAND POST

1. Control and supervise activity at the site to normalize the situation.
2. Warning to and evacuation of residents within the FH Order area.
3. Protection of life and property within the FH Order area.
4. Safety at the gas release site.
5. Monitoring gas concentrations within the FH Order area.
6. Security within the FH Order area.
7. Local weather information.
8. Technical gas release - related information.
9. Situation reports to Main Control Headquarters.

MAIN CONTROL HEADQUARTERS

1. Provide support to the On-Site Command Post. Compile monitoring information and evaluate.
2. Monitor gas concentrations outside the FH Order area.
3. Determination of the threatened area.
4. Safety of all workers in the threatened area.
5. Security and movement control within the threatened area except within the FH Order area.
6. Liaison, co-ordination and support to affected Local Authorities.
7. Warning and assistance to Local Authorities for evacuation and reception.
8. Situation reports to the Government of Alberta.
9. Situation reports to the On-Site Command Post.

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10. Information to the media.

11. Information to the public.

12. Health effects information.

13. Agricultural effects information.

14. Other environmental effects information.

15. Answer inquiries from the public.

16. Technical advisory services.

17. Obtain weather information.

EMERGENCY RESPONSE CENTRE (IF ACTIVATED)

1. Provide the co-ordinated Government of Alberta support to the Main Control Headquarters.

2. Arrange for any outside resources required by the Main Control Headquarters.

3. Arrange for resources of the Government of Canada or other outside governments, if required, to support the Main Control Headquarters.

4. Situation reports to the Main Control Headquarters.

5. Assume and exercise control of the total response (government, municipal, industrial) upon the declaration of a State of Emergency by the Lieutenant Governor in Council.

Annex D to
Government of Alberta
Peacetime Emergency
Operations Plan for a
Sour Gas Release

GOVERNMENT OF ALBERTA

RESPONSIBILITIES FOR SPECIAL SERVICES RELATED TO A SOUR GAS RELEASE

1. The following sets forth the responsibilities of Government of Alberta departments, boards, Bureaux and Crown agencies for providing special services related to peacetime emergency operations due to a sour gas release.

2. AGRICULTURE

a. Provide advice to the Main Control Headquarters regarding the effects of contaminents on agriculture and livestock and plants and soil.

b. Provide advice to the Main Control Headquarters on any mitigation procedures or arrangements to be effected.

c. Provide a representative to the Main Control Headquarters on a 24 hour basis, if requested by ERCB.

3. DISASTER SERVICES

a. Effect the Government of Alberta fan-out to alert all affected departments.

b. Alert all affected municipalities.

c. Confirm that "K" Division, RCM Police has been informed.

d. Provide a staff officer to the Main Control Headquarters on a 24 hour basis, if required.

e. Provide a Disaster Services Liaison Officer to the Main Control Headquarters.

f. Activate the Government of Alberta Emergency Response Centre if required.

g. Collect, collate and analyse the Government of Alberta peacetime emergency operations costs.

h. Co-ordinate reception plans for evacuation and reception municipalities.

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i. Inform Alberta Government Telephones of priority of emergency communications.

j. Make recommendations to Government regarding assistance to disaster victims and the sharing of costs of emergency or disaster operations.

k. Co-ordinate the preparation and regular review of the Sour Gas Release contingency plan.

4. ENERGY AND NATURAL RESOURCES

a. Provide emergency temporary accommodation and emergency feeding equipment, if requested by ERCB.

b. Provide assessment relating to all aspects of the renewable resources sector.

c. Provide advice to ERCB with regard to the firing of a sour gas release in the public lands.

d. Provide a representative to the Main Control Headquarters on a 24 hour basis, if required by ERCB.

5. ENERGY RESOURCES CONSERVATION BOARD

a. Alert the Government of Alberta to a sour gas release through Alberta Disaster Services.

b. Declare a sour gas release and inform Alberta Disaster Services, the RCM Police nearest the scene, the public threatened or potentially threatened, all Local Authorities whose geographic area is or might be affected by the release, Alberta Environment, Energy and Natural Resources, Workers' Health, Safety and Compensation and Alberta Disaster Services.

c. Determine the extent of the immediate hazard and issue an FH Order if considered necessary.

d. Direct the firing of a sour gas release if required.

e. Ensure the industrial operator is advising persons in immediate danger of high contaminent concentrations to evacuate by house-to-house contact (assisted by RCM Police and the Local Authority).

f. Supervise and control operations and mitigation activities within the FH Order area including the ordering of enforced evacuation and the control of access.

g. Arrange for the security of the FH Order Area.

h. Establish an On-Site Command Post and a Main Control Headquarters and direct the activities thereof.

j. Arrange for closure of airspace as required.

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6. ENVIRONMENT

a. Manage all sour gas monitoring activities except those activities for which Workers' Health, Safety and Compensation are responsible under the Occupational Health and Safety Act.

b. Determine areas at risk from the sour gas release.

c. Recommend evacuation to Main Control Headquarters of any areas where excessive levels of sour gas, as determined in consultation with Social Services and Community Health, are detected. (In emergency situations nearby residents will also be warned.)

d. When required, establish an appropriate weather facility in the vicinity of the sour gas release.

e. Provide representatives to the On-Site Command Post and the Main Control Headquarters on a 24 hour basis.

7. MUNICIPAL AFFAIRS

a. Provide damage and loss appraisals of property to affected citizens within the expertise of the department.

b. Manage the emergency response, including the declaration of a State of Local Emergency for those municipalities over which the department has direct control.

c. Provide a representative to the Main Control Headquarters on a 24 hour basis, if requested by ERCB.

8. PUBLIC AFFAIRS BUREAU

a. Keep the public informed by:

    (1) Making public information releases based on the situation report developed at the Main Control Headquarters;

    (2) making information releases regarding the general effects to health, safety and welfare; and

    (3) other information activities as considered desirable.

b. Assign a Public Affairs Officer to the Main Control Headquarters on a 24 hour basis and to the Emergency Response Centre, if activated.

c. Establish and staff a public inquiry centre with a publicized centre telephone number to support the Main Control Headquarters.

d. Establish a Public Affairs Management Control Centre at the Public Affairs Bureau responsible for all Public Affairs information coordination.

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9. SOCIAL SERVICES AND COMMUNITY HEALTH/PROVINCIAL BOARD OF HEALTH/LOCAL BOARD OF HEALTH

a. Establish health safety levels for the escaping contaminants. (see Annex E)

b. Monitor the health effects of the incident, to ensure appropriate data is collected and investigate such health effects. Advise on the appropriate remedial measures to be undertaken. May recommend further investigations after the event.

c. Provide health advice to those response organization personnel developing action guidelines for the levels of sour gas which could be involved in the release.

d. Provide health advice and safety levels for any health care or special care facilities and for the more vulnerable residents.

e. Provide advice to the government, particularly the Public Affairs Bureau representative at the Main Control Headquarters, on the existing or potential health effects of the incident.

f. Provide information to the public inquiry centre.

g. Provide a representative to the Main Control Headquarters on a 24 hour basis, if requested by ERCB.

h. Ensure that the necessary expertise, resources and information are available to local health authorities for them to carry out their role.

i. The local health authority ensures that individual members of the public are informed of specific risks and that appropriate health information is provided to Local Authorities and health care facilities.

10. SOLICITOR GENERAL

Through the RCM Police or a recognized police force:

a. Maintain law and order.

b. Warn and reinforce local police services, if required.

c. Notify the Alberta Disaster Services Duty Officer of a sour gas release.

d. Security control as required.

e. Act on behalf of the medical examiner in accordance with the Fatalities Inquiries Act.

f. Traffic and crowd control.

g. Provide a representative to the On-Site Command Post and Main Control Headquarters on a 24 hour basis.

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11. WORKERS' HEALTH, SAFETY AND COMPENSATION

a. Monitor the health and safety of all occupations at a work site, except agriculture, and ensure that necessary precautions are taken to protect the workers' health and safety during the emergency;

b. Ensure that equipment and personnel required for on-site evaluation of chemical levels are provided by the appropriate employers;

c. Provide information on toxic chemicals to the Main Control Headquarters; and

d. Provide a representative to the On-Site Command Post and the Main Control Headquarters on a 24 hour basis.

12. ALBERTA GOVERNMENT TELEPHONES

a. Provide emergency communications services to government departments as co-ordinated by Alberta Disaster Services.

b. Provide operating and maintenance personnel to ensure the continuity of emergency communications services.

16. Communications. The telephone will be the primary means of communications. Where practical the telephone will be supported by a "hard copy" capability either as an attachment to the telephone, telex or other means. Should additional communications arrangements be required, Alberta Government Telephones will be tasked to provide them. Alberta Government emergency communications requirements will be co-ordinated through Alberta Disaster Services.

17. Government of Canada Assistance. Requests for federal government assistance from any government department or agency, except where direct communications are authorized, shall be directed to Headquarters, Alberta Disaster Services, for transmission to the Regional Director, Emergency Planning Canada or to the Department of National Defence as necessary.

ANNEXES

Annex A - Sour Gas Release Emergency Response Organization

Annex B - Sour Gas Release Emergency Response Information Flow

Annex C - Sour Gas Release Functions

Annex D - Government of Alberta Responsibilities For Special Services Related To A Sour Gas Release

Annex E - Levels of Hydrogen Sulphide, Their Effects and Counteracting Measures

Annex F - Industrial Operator Responsibilities

Annex G - Glossary of Terms

Annex E to
Government of Alberta
Peacetime Emergency
Operations Plan for a
Sour Gas Release

LEVELS OF HYDROGEN SULPHIDE

THEIR EFFECTS AND COUNTERACTING MEASURES

1. At levels below 5 parts per million, people may experience effects such as headache, nausea, eye irritation and wakefulness. These are not serious and are reversible. Above 5 parts per million a health hazard may exist. The following action levels have therefore been established as a guide:

   a. When average levels exceed 5 parts per million for 6 hours or 10 parts per million for 1 hour or more and symptoms persist or become more severe, individuals should consider moving from the area.

   b. When average levels exceed 10 parts per million for 8 hours or more, local conditions in the area will be assessed and individuals may be advised to leave the area.

   c. When environmental monitoring indicates that a level of 20 parts per million or more will be reached and conditions indicate that a health hazard exists, urgent evacuation will be advised.

2. Similar information regarding other contaminants will be added. These stated levels are to be used as a guide only. Government health authorities will either confirm or amend these levels at the time of the sour gas release and in the light of information available at the time.

3. These levels of contaminents will be reviewed and may be adjusted after the publication of the Lodgepole Report.

Annex F to
Government of Alberta
Peacetime Emergency
Operations Plan for a
Sour Gas Escape

N.B. Although not a part of the plan, this Annex is included as information.

INDUSTRIAL OPERATOR RESPONSIBILITIES

1. Tell ERCB of the sour gas escape.
2. Fire sour gas if industrial operator procedures so state or if directed by ERCB.
3. Monitor contaminant levels downwind as directed by industrial operator procedures or ERCB.
4. Ensure residents near release site are notified of the hazard and evacuation guidelines.
5. Ensure that arrangements are made for transportation for the prompt evacuation of residents immediately at risk.
6. Notify residents of evacuation advice or order as directed.
7. Provide input to strategy for control of well.
8. Provide monitoring personnel and equipment.
9. Provide support and take such further action as directed by ERCB.

GLOSSARY OF TERMS

ERCB	Energy Resources Conservation Board
FH Order	Fire Hazard Order. Issued by ERCB to close off a specific area to unauthorized personnel.
Order of government	Municipal, provincial, federal
State of Emergency	Declaration by the Lieutenant Governor in Council to acquire additional powers under The Disaster Services Act to deal with an emergency or disaster
State of Local Emergency	A declaration by a Local Authority to acquire similar emergency powers to deal with an emergency or disaster

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